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Climate Change mitigation opportunities in the Energy sector for the Caribbean region

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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

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February, 2014

This report can be downloaded from www.uneprisoe.org and
http://www.acp-cd4cdm.org/publications.aspx

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http://www.acp-cd4cdm.org/
ISBN: **978-87-93130-05-0**

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ACKNOWLEDGEMENTS

We would like to express our gratitude for the valuable help of our colleague Denis Desgain who has helped with the translation process from Spanish into English and for his useful comments to improve the overall document. In addition, we would like to thank Federico Canu for his valuable help to edit and improve the graphics of the overall document.

Foreword

Capacity Development is one of the important elements of the means of implementation under the UNFCCC process towards achieving the 2oC goal. The demand for developing capacities for the clean development mechanism (CDM) was in the agenda of many cooperation agencies, including the European Commission. Beyond the CDM, however, due to the fact that many developing countries lack capacities to address increasingly complex scientific and technical issues to fulfill their obligations as signatories of multilateral environmental agreements (MEAs), the United Nations Environment Programme (UNEP) has joined forces with the European Commission (EC), the ACP Secretariat and several other partners to enhance the capacity of African, Caribbean, and Pacific (ACP) countries to implement MEAs. Capacity development for the CDM (CD4CDM) was one of the special components of the ACP MEAs Programme and was implemented by the UNEP Risoe Centre together with regional and local experts and the CDM Designated National Authorities (DNAs).

This study on “Climate change mitigation opportunities in the energy sector for the Caribbean region” has been prepared as part of the regional scope activities of the ACP MEAS – CD4CDM Programme. The aim of the Study is to provide Caribbean climate change practitioners and policy makers with value added information, in order to facilitate emission reductions in the energy sector, as part of the on-going and future scaling up efforts to apply and disseminate energy efficiency and renewable energy in the Caribbean.

By assessing the regions participation in the CDM and looking into the main bottlenecks for its application, the study presents a number of findings in terms of both constraints and prospects to alleviate the Caribbean countries dependency on fossil fuels, by means of energy efficiency, the application of low carbon technologies and the design and implementation of national energy policies supporting the former, in addition to the use and expansion of renewable energy.

The study was developed in collaboration with regional and local experts and the UNEP Risø Centre. The ACP-CD4CDM project hopes that this study provides the necessary information to the Caribbean countries in order to pursue their greenhouse gas emission reduction in the context of sustainable development.

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Glossary

ACM:	Approved Consolidated Methodology for (large-scale) CDM projects
ACP MEA:	Multilateral Environmental Agreements for Africa, the Caribbean and the Pacific
AD:	Anaerobic Digestion
°C:	Celsius degrees
CARICOM:	The Caribbean Community
CH_4:	Methane
CO_2:	Carbon dioxide
CO_2e:	Carbon dioxide equivalent
CER:	Certified Emission Reduction (equivalent to 1t CO_2e)
CDM:	Clean Development Mechanism
CPA:	CDM Program Activity
CUBAENERGIA:	Centre for Information Management and Energy Development
DE:	Diesel Engine
DNA:	Designated National Authority
DOE:	Designated Operational Entity
ECLAC:	Economic Commission for Latin America and the Caribbean
ENERDATA:	Global Energy & CO_2 Data
EC:	European Commission
EDGAR:	Emission Database for Global Atmospheric Research
FC:	Field Factor
GACMO:	Analysis tool developed by UNEP and the Stockholm Environment Institute
GDP:	Gross Domestic Product
GHG:	Greenhouse Gases
GMI:	The Global Methane Initiative
GT:	Gas Turbine
GTCC:	Gas Turbine Combined Cycle
GWh:	Gigawatts/hour
Inhab:	Inhabitants
H:	Hydropower
H_2O:	Water
IEA:	International Energy Agency
IPCC:	Intergovernmental Panel on Climate Change
IRENA:	International Renewable Energy Agency
km_2:	Squared kilometres
kWh:	Kilowatts-hour

LA&C:	Latin American and Caribbean
LCOE:	Levelized Cost of Energy
m:	Meter
$MtCO_2$:	Millions of tons of CO2
tCO_2e:	Ton of CO_2e
MW:	Megawatts
MWh:	Megawatts -hour
NAMA:	Nationally Appropriate Mitigation Action
N_2O:	Nitrous oxide
NREL:	National Renewable Energy Laboratory, USA
OAS:	Organization of American States
OLADE:	Latin American Energy Organization
GWP:	Global Warming Potential
PETROCARIBE:	Energy Cooperation Agreement between Venezuela and the Caribbean countries
PDD:	Project Design Document
PoA:	Program of Activities
PV:	Photo Voltaic
SEI:	Stockholm Environment Institute
SIDS:	Small Island Developing States
SIIE-OLADE:	Energy Information System of OLADE
ST:	Steam Turbine
TP:	Thermal Plant
UNEP:	United Nations Environment Program
UNFCCC:	United Nations Framework Convention on Climate Change
USD:	United States Dollar

Technical Summary

I. Introduction

1. The "Climate change mitigation opportunities in the energy sector for the Caribbean region" has been prepared as part of the implementation of the Caribbean Regional Subcomponent of the MEAs Program for Africa, the Caribbean and the Pacific (ACP MEAs)[1]. The study has being executed with the collaboration of a team of experts from CUBAENERGIA [2] and UNEP Risø Centre[3].

2. The objectives of the study are twofold, the provision of support to Caribbean Countries to actively consider participation in the Clean Development Mechanism (CDM); and the provision of value added information to decision makers in the region interested in linking energy-climate change benefits as part of the on-going and future scaling up efforts for Renewable Energy (RE) dissemination in the Caribbean.

3. The study is based on an analysis of the mitigation potential in 16 countries in the Caribbean Region, due to the interconnection of renewable energy to the grid, the modeling of in-country energy sector development and its associated emissions for different scenarios; that include both the "business as usual" and "mitigation" due to the scaling up of Renewable Energy Technology. The study also looks at the experience from participation in the CDM in the region and narrows on some of the perceived institutional challenges, especially from the perspective of Programme of Activities (CDM PoA) development in the field of renewable energy for the Caribbean Region, as precursors for evolving mitigation activities (under broader climate finance opportunities), by looking in closer depth at two potential PoAs in the region.

II. Major Findings of the Study

4. As well as many other SIDS [4], the Caribbean Countries are "heavily dependent on imported petroleum products, largely for transport and electricity generation. This is likely to continue in the short to medium term, however the efficiency of such use can be greatly increased through appropriate technology and national energy policies which promote more economic and environmentally beneficial energy use. Several constraints to the large-scale commercial use of renewable energy resources remain, including technology development, investment costs, available indigenous skills and management capabilities". Seven of the countries in the area are currently members of the International Renewable Energy Agency (IRENA)[5], with an additional three currently in the process of becoming members[6]. In this context, the electricity sector generation based on thermal fossil fuel based sources is in the order of 93.2% with renewable energy sources amounting to a mere 6.8% of total installed capacity (mainly from hydro resources in selected countries).

[1] http://www.acpmeas.info/
[2] http://www.cubaenergia.cu/
[3] http://www.uneprisoe.org/
[4] http://www.sidsnet.org/
[5] http://www.irena.org/home/index.aspx?PriMenuID=12&mnu=Pri
[6] Current IRENA members: Antigua and Barbuda, Belize, Cuba, Dominican Republic, Grenada, Saint Kitts and Nevis, Saint Vincent and the Grenadines; and countries currently in process to become members are: Barbados, Jamaica, and Saint Lucia.

Table A: Installed capacity by plant type in the Caribbean

Country	Generation (GWh)	Installed Capacity (MW)		
		Total	Thermal	Renewable Energy
Antigua and Barbuda[(a)]	314.6	90.2	90.2	n.a.
Bahamas	2,195.7	548	548	n.a.
Barbados	1,047.3	239.1	239.1	n.a.
Belize	7.6	82.9	47.2	35.7
Cuba [(b)]	17,395.5	5,852.6	5,782.4	70.2
Dominica	92.9	26.7	20.0	6.64
Dominican Republic	15,794.9	3,344	2,821	523
Grenada	205.8	55.8	55.8	n.a.
Guyana	765	348.5	348	0.5
Haiti	645.2	338	276	62
Jamaica	5,435.8	854	811	43
Saint Kitts and Nevis [(a)]	232.5	47.4	47.4	n.a.
Saint Lucia	380.8	76	76	n.a.
Saint Vincent and the Grenadines	156.4	36	28	8
Surinam	1,634.6	411	221	190
Trinidad and Tobago.	8,331.1	1,544	1,544	n.a.
Caribbean Total	54,636.1	13,894.24	12,955.2	939.04

Source: ENERDATA, 2012, except the indications: (a) - World Bank, 2010 (b) CUBAENERGIA

5. The Caribbean Countries have active agendas in the Energy Sector, both individually, as well as through their regional networks of organization and participation. In the energy sector, the "41st Special COTED on Energy celebrated in March 2013 in Trinidad & Tobago", approved the CARICOM Energy Policy[7] and provided a range of Mandates for Advancing Sustainable Energy Development including a series of important targets related to the scaling-up efforts for renewable energy participation in the energy matrix in the region: by 2017, achieve a 20% renewable energy capacity share and 18% reduction of CO_2 emissions from the power sector; by 2022, a 28% share of RE and 32% reduction in emissions; and by 2027, the target is to achieve a 47% share of RE in the energy sector together with a 46% reduction of emissions from the power sector and an overall 33% reduction in the energy intensity. At the country level there are many identified efforts to address key energy sector issues, both for renewable energy as well as energy efficiency policies/programs.

6. All of the countries considered in this study have ratified the United Nations Convention on Climate Change (UNFCCC) and the Kyoto Protocol (KP); all but two[8] have dully registered CDM Designated National Authorities, and one[9] has submitted a National Adaptation Programme of Action (NAPA). As part of the regional policy efforts linking energy and climate change, countries in the region are collaborating towards the establishment of regional targets for emissions reductions that are informed by international obligations and voluntary commitments under the UNFCCC and the Alliance of Small Island States (AOSIS) climate change negotiating strategy and objectives; the determination of Greenhouse Gas (GHG) baselines, the establishment of national emission reduction targets for voluntary commitment as nationally Appropriate Mitigation Actions (NAMAs); and in the identification of programs/projects that could be funded from resources available under the global climate finance opportunities including existing and new market mechanisms.

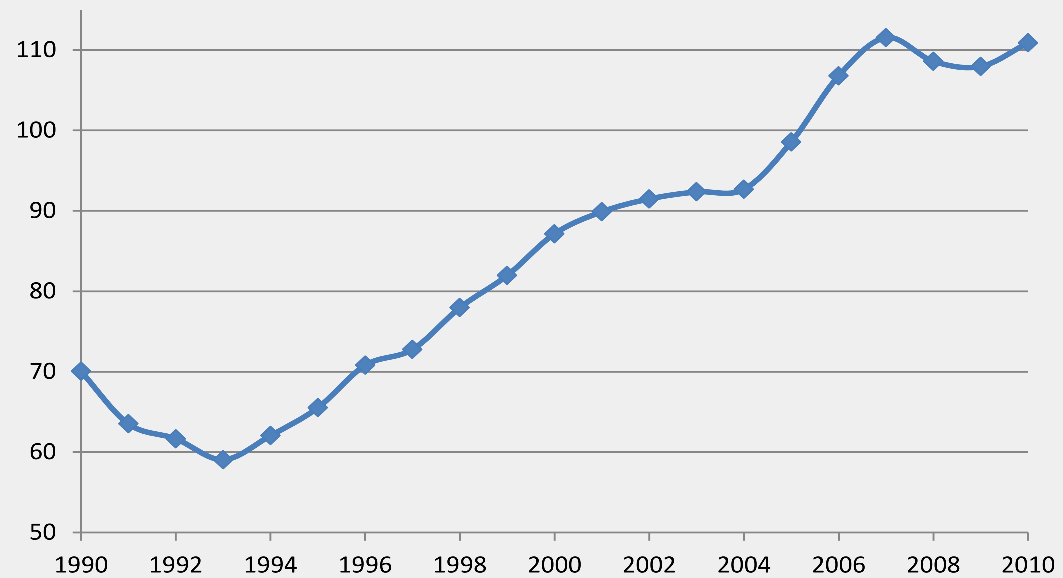
7. About 98% of GHG emissions in the Caribbean come from CO_2 in different sectors; energy representing about 82% of such emissions. Emissions from the energy sector in the region have scaled up over the last 20 years; and therefore carbon emission reduction

[7] CARICOM, 2013
[8] The only countries with no DNA registered to the UNFCCC are Saint Kitts and Nevis, and Saint Vincent and the Grenadines.
[9] Haiti has submitted, as an LDC a NAPA

opportunities in the sector should play an important role in any road map for development of climate change mitigation strategies at the regional as well as in-country level. Moreover emissions reductions from scaling up renewable energy technologies in the region need to be a central part of overall low carbon development paths.

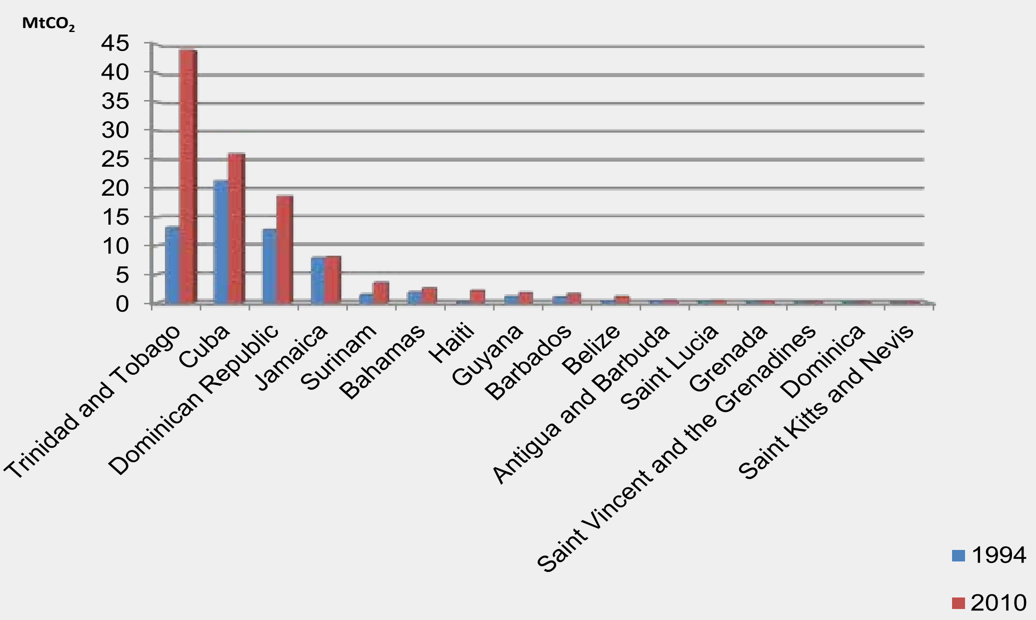
8. The Caribbean Region is well endowed with Renewable Energy Resources, and such potential has being/or is currently

Figure A: Evolution of CO_2 emissions in the Caribbean, from fuel combustion ($MtCO_2$)



Source: Elaborated by the authors based on ENERDATA and EDGAR databases and Greenhouse Inventories of National Communications submitted by the Caribbean countries to the UNFCCC.

Figure B: CO_2 emissions from fuel combustion by Caribbean country



Source: Elaborated by the authors based on ENERDATA and EDGAR databases being evaluated by different institutions and organizations. For the purpose of the initial data considered in this study, secondary sources of information have being considered mainly from NREL/OAS,[10] the PETROCARIBE Secretariat[11], and the Word Bank[12]. Some country-specific studies have also being used, such as Barbados[13], Belize[14], and Cuba[15].The potential RE resource in terms of MW is about 1.76 times the current installed capacity of around 13,894 MW in the whole region considered.

9. Both a baseline and a mitigation scenario have been developed in order to assess emissions reductions from scaling up of RE technologies. The baseline scenario describes a "business as usual" approach simulating future emissions due to the continuation of observed capacity addition practices observed in the region and in specific countries. The mitigation scenario takes into consideration capacity expansion needs and simulates RE target penetration in the order of 20% and 30% for 2020 and 2030 respectively for total electricity generation. The quantitative assessment of

Table B: Potential for the development of renewable energy in the Caribbean

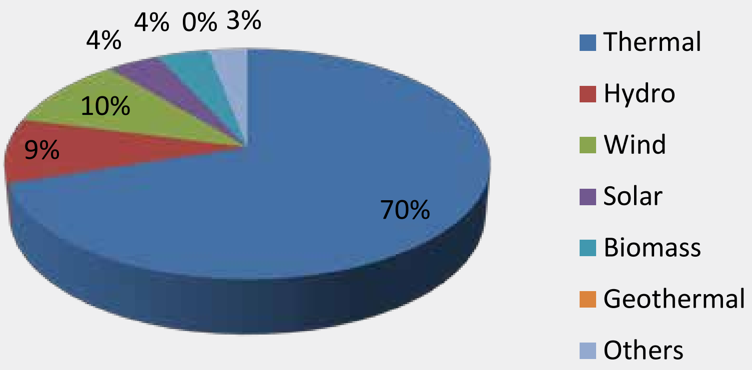
No.	Country	Hydro (MW)	Wind (MW)	Solar PV (MW)	Biomass (MW)	Geothermic (MW)	Others (MW)	Total potential (MW)
1	Antigua and Barbuda[(a)]	None indicated	400	27	Unknown	None indicated		427
2	Bahamas[(a)]	None indicated	58	58	1	None indicated		117
3	Barbados[(e+g)]	0	60	26			50	136
4	Belize[(c)]	46.4	250	40				336.4
5	Cuba[(d)]	848	2,005	2,110	1,340		2,185	8,488
6	Dominica[(a)]	17	30	45	Unknown	300		392
7	Dominican Republic[(b+g)]	2,095	3,200	2,899				8,194
8	Grenada[(a+g)]	0.5	20	21	Unknown	Unknown		41.5
9	Guyana	7,000	15.5	16				31.5
10	Haiti[(b+g)]	137	20	1,654				1,811
11	Jamaica[(f+g)]	25	70	650			40	785
12	Saint Kitts and Nevis[(a+g)]	None indicated	5	16	20	300		341
13	Santa Lucia[(a)]	0.15	40	36		170		246,15
14	Saint Vincent and the Grenadines[(a)]	10	8	23	4	100		145
15	Surinam[(b+f)]	2,420	12	36				2,468
16	Trinidad y Tobago[(h)]		500					500
	Caribbean	5,599.05	6,693.50	7,657	1,365	870	2,275	24,459.55

(a) OAE, 2011.
(b) http://siee.olade.org/siee/default.asp- OLADE – SIEE, 2010.
(c) UNEP Risø Centre, 2013.
(a) CUBAENERGIA, 2012.
(d) OLADE, 2008.
(f) PETROCARIBE- Estudio sobre Energías Renovables en El Caribe. Secretaria PETROCARIBE, Diciembre 2007.
(g) World Bank, 2010.
(h) OLADE, 2005. Prospectiva del Sector Energía en los Países de México, América Central y el Caribe.

[10] OAS, 2011
[11] Ramírez, 2007
[12] World Bank, 2010
[13] OLADE, 2008
[14] UNEP Risoe Centre, 2013
[15] CUBAENERGIA. 2012

mitigation potential (tons of CO_2) was performed separately for each country, taking into account specific conditions and portfolio of renewable resources available using the approach outlined on the “GACMO Analysis Tool” developed by UNEP Risoe Centre and the Stockholm Environment Institute (SEI).The calculation of the avoided mitigation potential is made based on unburnt fuel displaced by the introduction of renewable energy generation (which is consistent with National Greenhouse Inventory practices), rather than on an approach based on the establishment of country or regional electricity sector standardized baselines.

Figure C: Installed electric power capacity structure in the Caribbean by 2030



Source: Elaborated by the authors based on ENERDATA and EDGAR databases

10. The expected capacity additions required in the region towards 2030 amount to about 14,040 MW, which almost doubles the current installed capacity in the region. The modeling results for the wider region indicate that in order to achieve a proposed target of 30% participation from Renewable Energy generation, a total of 7,536 MW need to be installed by 2030 from RE technologies, of which 2,875 MW (38%) needs to be installed in the period up to 2020 and the remaining 4,661 MW (62%) in the next decade; coming from a diversified and challenging portfolio of sources and scales of technologies.

11. The accumulated emissions reduction mitigation to be achieved from the targeted Renewable Energy contribution analyzed in this work is on the order of 440.98 million ton CO_2 by the year 2030. Specific country required capacity additions from renewable energy technologies and their associated emissions reductions by 2020 and 2030 have being also detailed in the study. The top four countries in terms of potential total quantity of emissions reductions account for nearly 80% of the potential mitigation in the region, although the benefits from the scaling up of energy diversification reach down to all the countries.

Table C: Cumulative avoided GHG emissions from 2014 to 2030 (million tCO_2e)

Country	Renewable Energy Capacity Additions by 2020 (MW)	Accumulated CO_2 Emissions Reductions by 2020 (million tCO_2)	Renewable Energy Capacity Additions by 2030 (MW)	Accumulated Emission Reductions by 2030 (million tCO_2)
Antigua and Barbuda	30	0.97	25	2.93
Bahamas	100	3.06	100	6.96
Barbados	70	2.32	66	9.34
Belize	10	0.38	80	4.94
Cuba	1,000	17.34	1,800	123.88
Dominica	10	0.65	10	1.99
Dominican Republic	650	26.33	1,000	117.39
Grenada	20	0.85	25	3.69
Guyana	200	5.23	160	24.15
Haiti	50	4.13	160	19.84
Jamaica	235	6.86	300	31.42
Saint Kitts and Nevis	20	0.75	10	1.94
Saint Lucia	20	0.53	40	3.34
Saint Vincent and the Grenadines	10	0.70	25	2.85
Surinam	50	1.88	60	7.81
Trinidad and Tobago	400	15.08	800	78.49
Caribbean Total	2,875	87.05	4,661	440.98

Source: Elaborated by the authors.

12. The region wide specific envisaged participation by Renewable Energy Technologies and their associated emissions reductions by 2030 indicate that:

- *Wind Energy with 32% of new installed power with an estimated total of 2,450 MW and 146.5 million ton CO_2 of approximate reductions;*
- *Solar PV with 27.5% of new installed power with a total of 2,070 MW and associated reductions of 102.4 million ton CO_2;*
- *Hydropower with 20% of newly installed power with a total of 1,515 MW and associated reductions of 113 million ton CO_2;*
- *Bioenergy with 19% of new installed capacity totaling 1,390 MW and associated reductions of 71.48 million ton CO_2; and*
- *Geothermal Power with 1.5% of newly installed capacity, totaling 100 MW and associated emission reductions of 7.98 million ton CO_2.*

13. The associated investment required by 2030 is estimated at USD 21,725 million, based on IRENA[16] latest analysis of RE technology costing internationally. Achieving these objectives will require a major financing effort and barrier removal at the regulatory, investment, deployment levels. Taking into account the climate benefits associated to this

[16] IRENA, 2012.

level of scaling up, climate finance should be considered by decision makers in the region as an option to further up the leveraging opportunities for the required financing demanded.

14. As of November 2013, the Caribbean Region had only 26 projects (coming from 6 countries) that had entered into the pipeline in the Clean Development Mechanism (CDM), with 18 of those projects having being successfully registered in the mechanism and only 4 having issued CERs. Of this number, 18 projects were associated to renewable energy technologies, mainly at a scale larger than 15 MW; totaling around 851 MW and an associated capital investment of USD 1,100 million. It can be said that the relative participation of renewable energy projects in the CDM has been low in the region and that there has been important asymmetries between countries since most of the portfolio is concentrated in a few countries.

15. Although Programs of Activities (PoAs) were institutionalized in the CDM in order to create a vehicle to integrate emission reduction project activities types associated to small scale interventions with small amounts of emissions reductions each (characteristic of many renewable energy technologies in small power markets); and that in other areas of the world, especially towards the end of 2012, success had being achieved in registering these types of programs; the Caribbean Region has only submitted two Programs of Activities (PoA) under the CDM. The first one is the Petrotrin Oil Fields Associated Gas Recovery and Utilization PoA[17] which is registered and the other one is the Replacement of Traditional Charcoal Stoves with Efficient Echo Recho Stoves in Haiti[18] which is currently requesting registration in the CDM.

16. PoAs, have so far failed to be instituted as dissemination vehicles for small scale project activities in the Caribbean region although there is a clear potential for such schemes, especially as the region commits to large scaling-up efforts for renewable energy deployment. Experience elsewhere, during the CDM First Commitment Period has indicated that PoAs were a sound way to integrate small scale projects and emissions reductions and bringing them into the attention of carbon buyers; especially those now associated to the interest of some specific countries such as the European Union members as well as other emerging countries establishing transitional CER purchasing facilities.

17. Moreover, PoAs development approaches are gaining acceptance as interesting and appropriate platforms for the structuring of Nationally Appropriate Mitigation Activities (NAMAs) as part of the emerging context of new climate finance mechanisms for mitigation internationally, since monitoring and other aspects associated to programs involving renewable energies are well represented and understood from their carbon and mitigation components.

III. Institutional Barriers for Mitigation Activities

18. Important steps were taken by the Caribbean Countries in creating the required institutional capabilities required to participate in the CDM. All of the countries in the region signed and subsequently ratified the Kyoto Protocol. All but only two countries established their Designated National Authorities (DNA) to the CDM, signaling their interest in participating and hosting CDM projects. Mandates associated to the local DNAs included aspects related to the promotion of the CDM but mainly have stayed within the formal provision of Letters of Endorsement (LoE) to CDM project activities, except perhaps for the larger countries in the region where there was project activity in many sectors that could deliver climate mitigation projects in different sectors. The DNA structuring process and associated strengthening has not necessarily proven an easy thing taking into account that the CDM project efforts in many countries in the region have not being very active on the part of both local and international developers, that the existing climate change offices and institutions within countries tend to be vulnerable and overloaded with many other issues related to UNFCCC processes, and the fact that in many countries the climate change adaptation angle receives more attention (due to the obvious vulnerability of the countries).

[17] http://cdm.unfccc.int/ProgrammeOfActivities/poa_db/VOJCMND3RBQ0I692KWH8YPT4ESGFZ1/view
[18] http://cdm.unfccc.int/ProgrammeOfActivities/poa_db/45N2WHPB9DJYUFTELKR8ZIC7OQSAM6/view

19. During early stages of the CDM, most of the work done by in-country DNAs revolved around the promotion of the mechanisms within sectors in different scopes of interest (energy, solid waste management, cement, etc.). Surely, DNAs in the largest countries in the Caribbean conducted different types of activities related to such promotion and awareness of the CDM. Moreover, some countries called-in for project proposals on mitigation as an attempt to jump start the flow of projects in the CDM. The reality indicates that it was a combination of pro-positive actions on behalf of certain countries speeding up formal approval procedures, but also and largely on the opportunity sought by specific project developers interested in accessing complementary carbon incomes that drove the effort for CDM projects in the region.

20. Several reasons may explain the low uptake of renewable energy projects within the CDM in the region; some of those reasons are within the realm of how renewable energy projects are developed in the area; and others may be related to the CDM itself and its institutional/market frameworks. On the project development side, the energy sector in many of the countries has very complex institutional/political economies setups, couple to cumbersome regulatory and approval processes. Therefore project development activities take time and frequently there are important delays in clearing all the barriers and hurdles confronted by the RE project developer. Success in the CDM has been linked to appropriate timing between project development activities and the CDM approval process. Many of the projects in the Caribbean did not have the adequate timing and therefore opportunities have been missed in several countries.

21. On the side of the CDM institutions/markets several issues may explain the low CDM up-take in the region:

- *During a good part of the CDM history since its entry into force until the end of 2012, CDM approval complexities as well as high transaction costs where the norm, not being until the end of such period that project developers really witnessed efforts on the part of the CDM Executive Board to remove some of those perceived barriers; therefore project developers in the region decided to concentrate in advancing their projects locally rather than seeking a complex and expensive CDM process.*
- *Carbon market players seeking to arrange compliance portfolios decided to concentrate on “low hanging fruits” in countries and sectors where they saw scaling-up opportunities for those portfolios. The Caribbean showed mostly “one of a kind” projects in many countries, and coupled with perceived legal issues in arranging carbon contracts in those countries; carbon buyers moved to only look at the larger countries in the region; perhaps except by the role played by regional multilaterals that actively seek a carbon portfolio in the Caribbean associated to their project lending activities.*
- *The CDM Designated National Authority (DNA) experience in the region has been mixed. Although normally chartered with promotion as well as approval responsibilities (as formally required by the CDM), only DNAs in the larger countries saw a space and opportunity to go out and promote effectively the mechanism with the right constituencies of effective project developers. In smaller countries within the region, on the other hand, the climate change focal points took on the task of facilitating the internal processes towards national approval of any CDM project, and therefore concentrated mainly in responding to the expressed interest of specific project proponents (probably righty so due to their lack of adequate staffing needs, and the urgency to respond to pressing demands from other areas within their participation in the UNFCCC process). Not having had hands-on experience in such CDM approval matters earlier on, it is in the smaller countries where most difficulty is faced by project developers in going through a CDM national approval process.*

22. Although DNAs in the region have been very supportive of the PoA concept, it has to be recognized that PoAs involved a rather more complex set of stakeholders since they introduced the figure of the Coordinating Managing Entity (CME) of the PoA which

is not necessarily the previous figure of the project developer. Therefore any development of PoAs in the region needs to pass through the strengthening of Coordinated Managing Entities (CMEs), and above that which types of partnerships will need to be promoted with a capacity to provide value added to energy sector program activities. Although this is not an outstanding issue from the point of view of DNAs, the lack of identified CMEs from within the region may be an important stumbling block for further development of PoAs in the region under the Kyoto Protocol track of climate finance.

23. As climate change moves from a concern into a reality exemplified by the permanence of climatic stresses and there is a need for further responses at many levels, including further mitigation efforts; there is a renewed need to look at the required institutional issues for an adequate response to the emerging paradigms. Mitigation efforts are beginning to move from the project based approach to the sectoral approach, climate financing for mitigation is moving from the sole CDM into expanded New Market Mechanisms (NMM) and Nationally Appropriate Mitigation Actions (NAMAs). Furthermore, climate change policy is synergistically linking into other mainstream policies around Low Carbon Development Strategies (LCDS), one area of which is the energy sector. The Caribbean is not absent from this new climate language as its most recent regional policy development in the energy sector, links climate change policies with energy sector policy.

24. Climate Change institutions and related policy making in the region will have to adjust and evolve under the new emerging opportunities. Important areas of attention for climate change institution development and strengthening in the near future need to be considered:

- *The need for new institutional leadership and capacity building as the climate action agenda furthers up and streamlines into broader incidence at the country level, not only at the traditional UNFCCC level.*
- *The emerging opportunity to engage leadership and establishment of required partnerships for action on climate change mitigation, taking advantage of new windows of opportunity within climate financing and assisting in leveraging most needed resources for barrier removal towards scaling up renewable energy up-take in the region.*

Key Conclusions and Recommendations

25. As the Caribbean Region commits to longer term targets for scaling up renewable energy contributions to the power sector, this study contributes by providing levelized information on a country by country basis on the climate mitigation resulting from the incorporation of up to a 30% penetration rate from Renewable Energy Technologies in electricity generation to the year 2030. It is as such one of the first region-wide efforts looking at the climate change benefits resulting from the scaling-up of RET under a low carbon development path in the energy sector in the region.

26. The findings of the study indicate that the mitigation component of such a major scaling-up are on the order of up to 440 million tons of CO_2 by 2030, figure that is relevant and significant within the regional energy sector emission profiles. Taking into account new emerging opportunities for climate mitigation finance such as pilot NAMA facilities as well as, under discussion, new market mechanisms; there is a space for leveraging resources that could prove to be synergistic in supporting the removal of barriers for the implementation of region wide efforts to scale-up the up-taking of renewable energies.

27. It seems to be a good time to hold a regional discussion towards establishing a road map for the envisioned support expected within the region from emerging and existing climate finance mechanisms, including carbon markets; in order to assess what leverage and degree of engagement climate offices in the region should have in focusing opportunities for climate mitigation funding opportunities identified. Based on such discussion a new road map should emerge on how the region proposes to gain incidence within existing and emerging climate mitigation financing opportunities in order to secure the formation of financial facilities that can leverage resources at the scale needed in order to remove barriers for Renewable Energy uptake in the region.

1. Introduction

In recent years, the problem of climate change has caught unprecedented attention resulting in an international mobilization to agree on mechanisms and measures to mitigate its effects and to look ways to find a solution. As one of the milestone in the search of global solutions among the world countries to deal with the climate change issue was the creation of the United Nations Framework on Climate Change (UNFCCC) in 1992.

In the last fourth and fifth Assessment Reports of the Intergovernmental Panel on Climate Change (IPCC) clearly indicated that the increase of the global temperature is result of the increase of the overall greenhouse gases concentrations in the atmosphere due to human activity (IPCC, 2013). Therefore the necessity to reduce the overall GHG concentrations in the atmosphere has become of primordial importance in order to not exceed the 2 °C by 2100, limit that according to the IPCC will have catastrophic consequences to the ecosystems and living organisms on planet Earth.

Therefore the Parties, which are part of the UNFCCC, have been negotiating since its creation on the best mechanisms to reduce the GHG emissions resulting from human induced activities. However, it is not since after the Kyoto Protocol that we can observe real GHG emission reductions in the developed and developing countries. Despite this effort and due to the observed increase in the overall temperature and the evidence of the increase of the extreme weather events is that the countries embarked in 2007 in a negotiation process in order to deepen overall mitigation efforts.

Nevertheless, it is important to stress that the countries will need to work at the same time on mechanisms to adapt to climate change. This is a relevant issue for island countries such as those from the Caribbean region which are threaten mainly by the increase of the sea level and the increase in the number and in the intensity of the hurricanes. Even though the adaptation could play an important role to reduce the climate change impacts, if the overall GHG emission continues to increase as they have been doing the adaptation will not be enough to cope with the climate change impacts. Thus, it is essential that everyone contributes to reduce its GHG emissions with respect to their historical responsibilities and taking into account the development priorities of the developing countries.

The present publication is an effort of the ACP-MEAs project to analyze the mitigation potentialities that the Caribbean region could offer to the world as mitigation efforts to reduce its overall GHG emissions coming from the Energy generation.

2. Objectives of the study

This document has been prepared as part of the Caribbean sub-regional project that is implemented within the Multilateral Environment Agreements (MEAs) Strengthening Program for Africa, the Caribbean and the Pacific (ACP), known by its acronym in English ACP MEAs. The initiative sponsored by the European Commission (EC), the United Nations Environment Program (UNEP), and UNEP Risoe Center has supported a total of 14 countries: seven from Africa (Angola, Botswana, Ivory Coast, Malawi, Nigeria, Rwanda, and Sao Tome and Principe), three from the Caribbean (Belize, Cuba and Trinidad and Tobago) and two from the Pacific (Fiji and Papua New Guinea) The objective is to actively promote the participation in the carbon market, using the Clean Development Mechanism (CDM). In order to reach this goal, the CDM capacity building element is focused on helping countries with the identification, preparation, adoption and structuring of potential CDM candidate projects, as well as with the support for the implementation of sound in-country frameworks of enabling activities for participation. Furthermore, the initiative has provided support in order to implement, monitor and adopt CDM projects, in addition to their contribution to achieve national priorities and sustainable development in the countries.

In the Caribbean region, the Programme was implemented on two different levels: i) to strengthen the capacity of national institutions for CDM in Cuba, Belize and Trinidad and Tobago, and ii) to identify the potential for programmatic CDM at a regional level. Regarding to the second level, it was intended to identify the some of the main mitigation potentials in the Caribbean due to grid-connected renewable energy scaling-up opportunities. Based on this process, a potential Programme of Activities (PoA) was identified, as well as a corresponding first CDM Programme of Activities (CPA) under CDM for the Caribbean region.

The objectives of the present study are the following:

1. To conduct an analysis of the mitigation potential in the Caribbean resulting from grid-connected renewable energy.
2. To assess the participation of the Caribbean in the Clean Development Mechanism.
3. To evaluate sectors that could contribute to potential actions directed at mitigating climate change in the Caribbean.
4. To conduct studies of potential mitigation actions within the Caribbean context.

3. Regional environment in the Caribbean for the integration and connection of renewable energy to the grid

The Caribbean region is widely regarded as the Arch of the Greater and Lesser Antilles. In many cases, various other countries are included into the social and economic studies of the area because they form part of regional organizations. However, in this study the Caribbean region refers to the following countries (Figure 1):

1. Antigua and Barbuda	**9. Haiti**
2. Bahamas	**10. Jamaica**
3. Barbados	**11. Dominican Republic**
4. Belize	**12. Saint Kitts and Nevis**
5. Cuba	**13. St. Lucia**
6. Dominica	**14. Saint Vincent and the Grenadines**
7. Granada	**15. Surinam**
8. Guyana	**16. Trinidad and Tobago**

Figure 1: Map of the Caribbean region subject of study

Source: commons.wikimedia.org

3.1 General characterization of the region

The area of study includes 16 Caribbean countries, covers a surface of about 62,000 km[2,] and has a population of nearly 38 million people. In 2010 the region generated a Gross Domestic Product (GDP) of nearly USD 160 billion at constant prices of 2005 (Table 1). The average GDP per capita in the region was of USD 7,554. Although this figure does not reflect the large differences among the countries. We may find per capita figures over USD 21,000 in Bahamas and less than USD 500 in Haiti.

Table 1: Territory, population and GDP by countries in the Caribbean

Nº	Country	Land area Km² [(b)]	Population 2010 10^3 inhab[(a)]	GDP 2010 10^6 USD 2005 [(a)]	GDP 2010 per inhabitant[(a)] USD 2005
1	Antigua and Barbuda	443	89	1,012.7	10,730.5
2	Bahamas	13,940	343	7,461.1	21,840.8
3	Barbados	431	273	4,055.3	14,870.7
4	Belize	22,966	312	1,258.7	4,052.1
5	Cuba	110,860	11,298	55,436.5	5,040.3
6	Dominica	754	68	432.0	6,364.8
7	Grenada	344	9,907	47,246.6	4,918.8
8	Guyana	214,970	104	672.8	6,476.8
9	Haiti	27,750	754	1,627.5	2,269.7
10	Jamaica	10,991	9,884	4,307.7	454.4
11	Dominican Republic	48,442	2,741	11,058.3	4,070.5
12	Saint Kitts and Nevis	261	52	548.8	10,566.8
13	Saint Vincent and the Grenadines	389	174	1,067.2	6,139.3
14	St. Lucia	616	109	591.9	5,419.9
15	Surinam	163,270	525	1,897.6	3,742.3
16	Trinidad and Tobago	5,128	1,341	18,977.5	13,902.3
Total		62,155.5	3,797.4	157,652.2	Average 7,553.8

Source: a) ECLAC, 2012; b) CELAC, 2013

The 16 countries included in the study are classified within the group of Small Island Developing States (SIDS).

As can be observed, the Caribbean region subject is made up of three groups of countries, which have similar characteristics:

- Cuba, Dominican Republic, Haiti and Jamaica have larger territories; their populations exceed nine million inhabitants, except Jamaica which has 2.7 million. The tourism sector represents an important part of their economies (excluding Haiti). Nevertheless the structures of their economies are diverse and complex. The per capita income for this group lies between USD 4,000 and 5,000, with the exception of Haiti which has a per capita income below USD 500, being the lowest in the region.
- Guyana, Suriname and Belize are continental countries with a population under 800,000 inhabitants and areas larger than 160,000 km², except for Belize with an area of approximately 23,000 km². Forests coverage is large, in general over 70% of the territory, except for Suriname which has 90% forest coverage.
- Antigua and Barbuda, Bahamas, Barbados, Dominica, Grenada, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines and Trinidad and Tobago: Except Trinidad and Tobago, all the countries have limited territories, not exceeding 760 km². Bahamas however covers 13,940 km². The territories are sparsely populated, with none exceeding 350,000 inhabitants. All the economies rely on tourism. In this group, the case of Trinidad and Tobago is an exception as it is the largest

country (5,128 km^2), has the higher population (1.33 million people) and its main economic livelihood is based on the oil and natural gas industry.

It is well known that small island states are a complex mixture of physical, biological, demographic, economic and climatic characteristics. The limited land areas, the extensive exclusive economic zones, the increasing pressure exerted by tourist flows; biodiversity with high rates of endemism, restricted access to fresh water and the variety of geological and climatic attributes simultaneously offer a rich variety of natural resources and options for economic growth and sustainable development.

The problems caused by natural hazards in the Caribbean region, can be worsened due to the increase of the extreme events produced by the global warming. The expected increase of the sea level combined with the expected increase of the temperature in the sea surface would lead to the destruction of coral reefs, saltwater intrusion, changes in rainfall patterns, winds, ocean currents and other extreme weather events for the region such as tropical storms and hurricanes. Thus making the region highly vulnerable to the effects of global climate change.

3.2 Energy characterization of the region

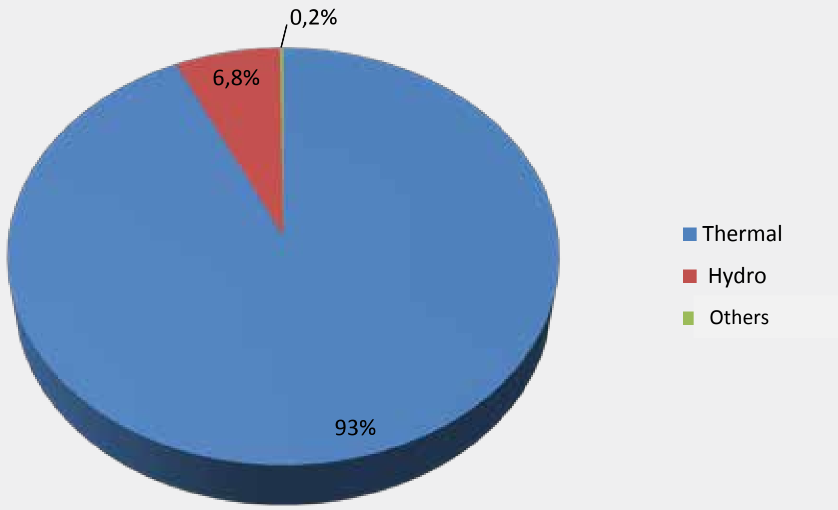
The small island states of the Caribbean are highly dependent on fossil fuels for the generation of electricity. Table 2 shows the installed capacity by type of plant in the Caribbean.

Table 2: Installed capacity by plant type in the Caribbean

Country	Generation (GWh)	Installed Capacity (MW)		
		Total	Thermal	Renewable Energy
Antigua and Barbuda[(a)]	314.6	90.2	90.2	n.a.
Bahamas	2,195.7	548	548	n.a.
Barbados	1,047.3	239.1	239.1	n.a.
Belize	7.6	82.9	47.2	35.7
Cuba [(b)]	17,395.5	5,852.6	5,782.4	70.2
Dominica	92.9	26.7	20.0	6.64
Dominican Republic	15,794.9	3,344	2,821	523
Grenada	205.8	55.8	55.8	n.a.
Guyana	765	348.5	348	0.5
Haiti	645.2	338	276	62
Jamaica	5,435.8	854	811	43
Saint Kitts and Nevis [(a)]	232.5	47.4	47.4	n.a.
Saint Lucia	380.8	76	76	n.a.
Saint Vincent and the Grenadines	156.4	36	28	8
Surinam	1,634.6	411	221	190
Trinidad and Tobago.	8,331.1	1,544	1,544	n.a.
Caribbean Total	54,636.1	13,894.24	12,955.2	939.04

Source: ENERDATA, 2012; (a) World Bank, 2010; (b) CUBAENERGIA, 2012

Figure 2: Installed capacity structure in the Caribbean



Source: ENERDATA, 2012; (a) World Bank, 2010; (b) CUBAENERGIA, 2012

Figure 2 shows that 93 % of the installed capacity in the Caribbean is thermal energy, only the remaining 6.8 % is hydro and wind energy.

The energy consumption in the small island states increases steadily due to several factors. In most of the countries, the use of fossil fuels has grown as a consequence of shifting the economy from agriculture to industry and services. The high dependence of fossil fuels for energy generation combined with continuos increase of the international oil price generates particular conditions for energy generation in the Caribbean nations.

Regarding the three main groups, which conforms the region from an energy point of view it can be concluded that:

- Cuba, the Dominican Republic, Haiti and Jamaica: are highly dependent on imported oil with more than 93% of the total electricity generated from fossil fuels. However some of them use renewable energies of a mainly traditional type like hydro with other non-traditional renewable like wind, biogas and solar slowly gaining some space in the generation matrix. In the case of Haiti, there is a significant use of wood as traditional biomass used for cooking purposes. The use of renewable sources does not exceed 7% of the generation matrix of the electricity systems.

- Guyana, Suriname and Belize: In this group of countries the electric generating capacity that is based on fossil fuels is lower, representing around 73% of all installed generating capacities. The use of renewable sources amounts to 27% in this group of countries, mainly hydro based due to the somehow important water resources available, and that are being exploited in order to reduce dependency to imported fuels for electricity generation.

- Antigua and Barbuda, Bahamas, Barbados, Dominica, Grenada, St. Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines and Trinidad and Tobago. These countries have the highest energy dependence on hydrocarbons. The electric generating capacity based on fossil fuels exceeds 99%, thus making them highly vulnerable to fluctuations of oil prices. Trinidad and Tobago, a major producer and exporter of oil and gas, is an exception.

The response of both countries and regional coordinating bodies regarding energy issues indicates an important expectation of the role of renewable energy in the region. There is a significant level of activity in terms of setting goals for renewable energy at both country and regional level. An example illustrating this argument is the adoption of penetration of renewable energy goals by CARICOM[19] countries, which have predicted a 20% penetration by 2017, 28% by 2022 and 47% by 2027.

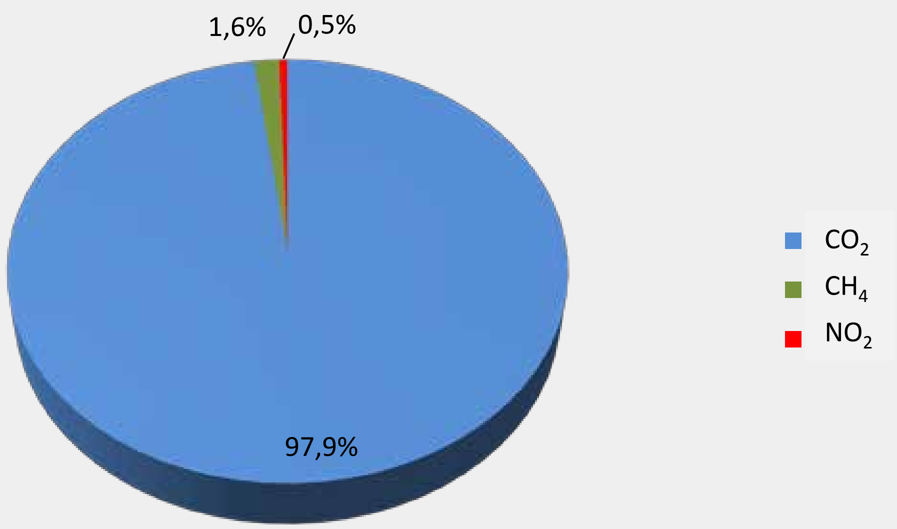
All being said, it is important to state that solutions to the energy situation in the region will have to acknowledge the circumstances, differences and similarities within the types of energy systems and boundary conditions described here, making the understanding of the complex set of emerging issues a very important step in assessing the contribution to be expected from renewable energies.

3.3 Greenhouse Gases Emissions from the Energy sector in the Caribbean

Given the dominant role which fossil fuels play in the generation of electricity in Caribbean, this sector is the largest contributor to greenhouse gas emissions in the region.

The reports of the National Communications submitted by the Caribbean countries were used to adjust an estimation of the overall GHG emissions (CO_2, CH_4 and N_2O) for the country reference year, which was 1990. Later on an additional adjustment was made to standardize emissions to the year 1994 using EDGAR, ENERDATA and other complementary databases.

Figure 3: Shows these calculations, which illustrate that almost 98% out of the emissions correspond to CO_2

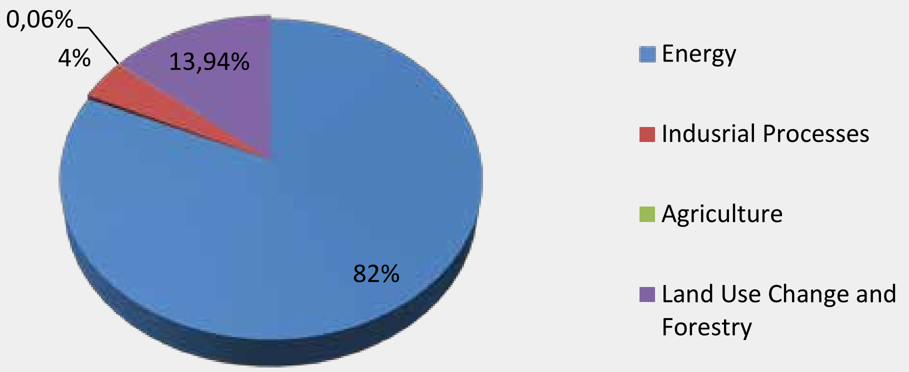


Source: Elaborated by the authors based on ENERDATA and EDGAR databases

[19] CARICOM, 2013

The distribution of the total gross CO_2 emissions by sources as established by the standard methodology[20] is shown in Figure 4. It is possible to notice that over 80% corresponds to the energy sector.

Figure 4: CO_2 Emissions in the Caribbean by sources



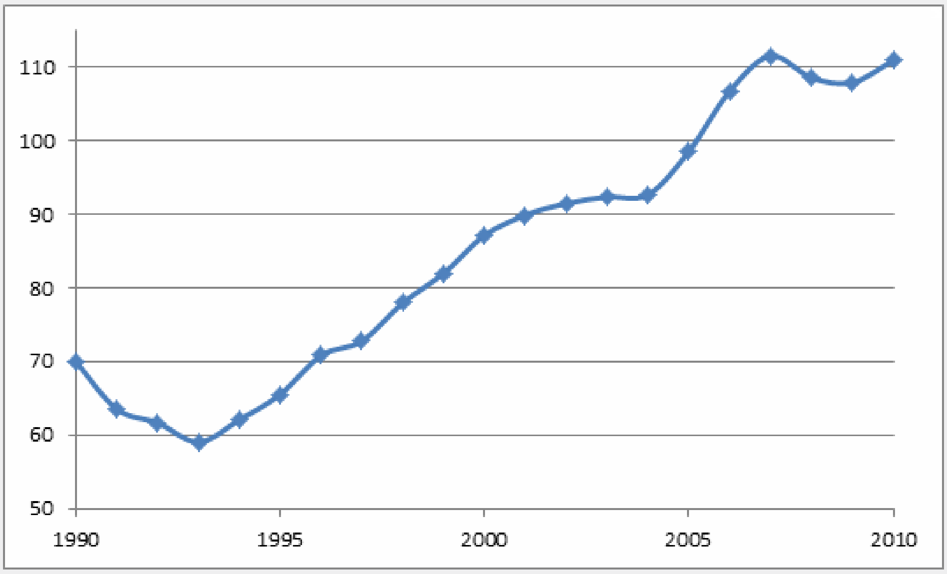
Source: Elaborated by the authors based on ENERDATA and EDGAR databases

In light of this fact, an analysis of the evolution of CO_2 emissions from combustion was carried out in the region of study using the ENERDATA[21] database.

In the case of countries such as Antigua and Barbuda, Belize and St. Kitts and Nevis, there was no data in the ENERDATA database. Emissions from fuel combustion were therefore calculated using the EDGAR[22] database.

Figure 5 shows the evolution of CO_2 emissions from fuel combustion in the region under study.

Figure 5: Evolution of CO_2 emissions in the Caribbean from fuel combustion ($MtCO_2$)



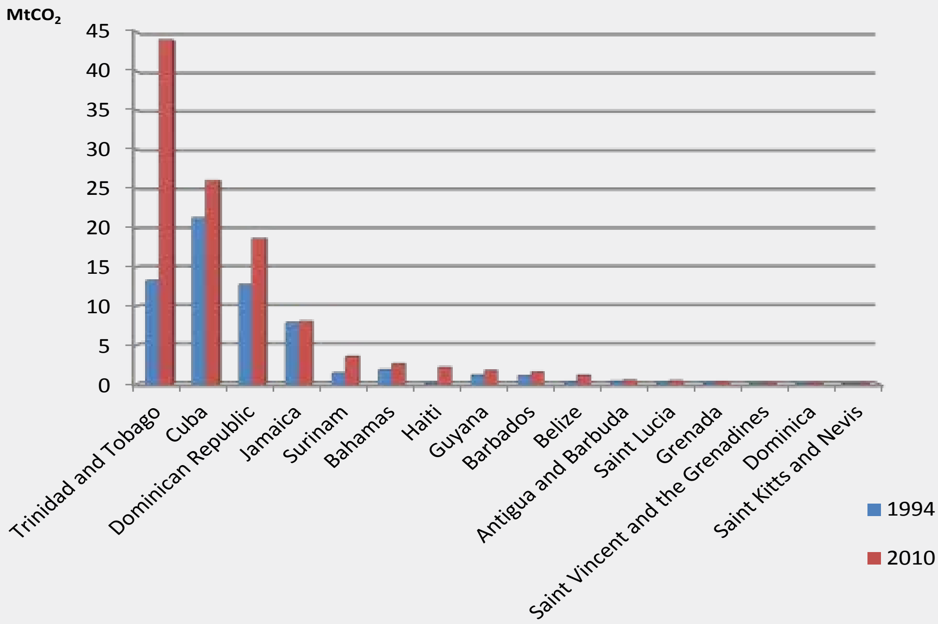
Source: Elaborated by the authors based on ENERDATA and EDGAR databases and Greenhouse Inventories of National Communications submitted by the Caribbean countries to the UNFCCC.

[20] IPCC, 1996
[21] ENERDATA, 2012. www.enerdata.net
[22] EDGAR database - version v4.2. http://edgar.jrc.ec.europa.eu/index.php

As shown in the region of study, there was a 2.4% annual increase in CO_2 emissions in the period between 1990 and 2010 due to fuel combustion.

Figure 6 shows the change in CO_2 emissions from fuel combustion by country for the years 1994 and 2008, taking as reference the results of the EDGAR[23] database.

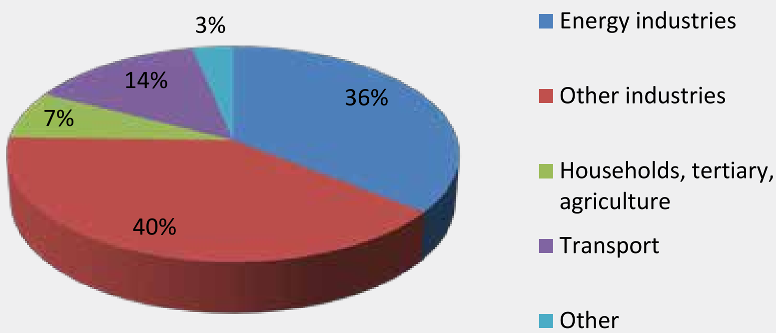
Figure 6: CO_2 emissions from fuel combustion by Caribbean country



Source: Elaborated by the authors based on ENERDATA and EDGAR databases

From the figure 7 could be extracted that the main GHG emissions comes from the fuel combustion of the “energy industries” and “other industries”, it becomes evident that the main emission contributors are the “energy industries”, and ”other industries”, which account for almost 75% of all CO_2 emissions.

Figure 7: CO_2 emissions from fuel combustion by sectors in the Caribbean



Source: Elaborated by the authors based on ENERDATA and EDGAR databases

[23] EDGAR database - version v4.2. http://edgar.jrc.ec.europa.eu/index.php

In 2010 emissions from the energy industry accounted for 39.6 $MtCO_2$ and represents 35.7% of the entire fuel combustion emissions of that year.

3.4 Conclusions

The Caribbean is a diverse region with significant dilemmas to achieve the sustainable development. Due to the existing diversity of natural resources and visions on how to achieve the sustainable development in the different countries of the region.

The electricity sector in the Caribbean countries may differ in capacities, but shares some common features: an accelerated demand growth, the historical and technological dependency on fossil fuels which shows the tendency for small capacity diesel plants in the region. When the oil prices are low they represent the most suitable alternative to energy generation. Nevertheless, nowadays due to the current oil prices they are affecting the economy of the countries and thus are affecting the economic activities and the country currency. However today they represent strong bonds of dependence on fossil fuels, which also rule the countries´ foreign exchange.

From the perspective of GHG emissions, the Caribbean has a minor contribution compared to global GHG emissions. Its emissions mainly come from fuel combustion in the electricity generation sector, which together with the industry sector represents approximately 80% of total GHG emissions of the region.

These sectors as the main energy consumers and the main drivers of the country economic development, could be subject to interesting climate mitigation actions that could significantly contribute to achieve energy security goals and energy diversification for regional countries. Thus it seems important that mitigation actions to control both supply and demand should be considered at any of the stages of mitigation actions either through technology transfer schemes or the use of market instruments, with support stemming from the UNFCCC, multilateral, bilateral actions or specific investments.

4. Mitigation Potential in the Caribbean region

4.1 Renewable Energy Potential in the Caribbean

In order to properly assess the potential climate change mitigation due to the scaling-up of grid connected renewable energy in the region, an updated assessment of the potential for renewable energies is presented in this section of the study.

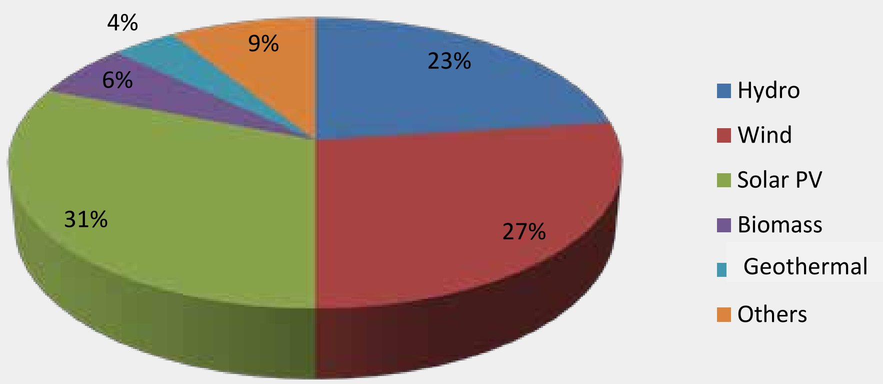
Data for the evaluation of renewable energy potential in the Caribbean have been collected from secondary sources available from several studies carried out by different institutions in different Caribbean countries, including: a study on energy policy and sector analysis in the Caribbean made by NREL and OAS[24] - a study on renewable energy in the Caribbean made by the PETROCARIBE Secretariat[25] - and a study on Caribbean Regional Electricity, Generation, Interconnection, and Fuels Supply Strategy carried out by the Word Bank[26] .

In the case of Barbados[27] - Belize[28] - and Cuba[29] country-specific studies have also been used as referenced sources.

In addition, data have been retrieved from the SIEE-OLADE[30] and ENERDATA[31] databases (already referred to in previous chapters).

Table 3 and Figure 8 show the data collected and used in the study. The blank spaces in the table do not mean that the resource does not exist in the country, but that no reference was found for it. The total of renewable energy available in the Caribbean region is estimated to 24,459 MW, which is 1.76 times the current installed capacity (13,894 MW). In regards to the 939 MW of renewable capacity currently installed in the region, only 3.8% of the renewable potential in the region has been used.

Figure 8: Renewable resource estimate for the Caribbean region



Source: Elaborated by the authors based on UNEP Risoe Centre, 2013; ENERDATA, 2013; Cubaenergía, 2012; OLADE, 2012, 2008; OAS, 2011; World Bank, 2010; Ramírez, 2007.

[24] OAS, 2011
[25] Ramírez, 2007
[26] World Bank, 2010
[27] OLADE, 2008
[28] UNEP Risoe Centre, 2013
[29] CUBAENERGIA, 2012
[30] http://siee.olade.org/siee/default.asp
[31] http://www.enerdata.net/

Table 3: Potential for the development of renewable energy in the Caribbean

No.	Country	Hydro (MW)	Wind (MW)	Solar PV (MW)	Biomass (MW)	Geothermic (MW)	Others (MW)	Total potential (MW)
1	Antigua and Barbuda[(a)]	None indicated	400	27	Unknown	None indicated		427
2	Bahamas[(a)]	None indicated	58	58	1	None indicated		117
3	Barbados[(e+g)]	0	60	26			50	136
4	Belize[(c)]	46.4	250	40				336.4
5	Cuba[(d)]	848	2,005	2,110	1,340		2,185	8,488
6	Dominica[(a)]	17	30	45	Unknown	300		392
7	Dominican Republic[(b+g)]	2,095	3,200	2,899				8,194
8	Grenada[(a+g)]	0.5	20	21	Unknown	Unknown		41.5
9	Guyana	7,000	15.5	16				31.5
10	Haiti[(b+g)]	137	20	1,654				1,811
11	Jamaica[(f+g)]	25	70	650			40	785
12	Saint Kitts and Nevis[(a+g)]	None indicated	5	16	20	300		341
13	Santa Lucia[(a)]	0.15	40	36		170		246,15
14	Saint Vincent and the Grenadines[(a)]	10	8	23	4	100		145
15	Surinam[(b+f)]	2,420	12	36				2,468
16	Trinidad y Tobago[(h)]		500					500
	Caribbean	5,599.05	6,693.50	7,657	1,365	870	2,275	24,459.55

(a) OAE, 2011
(b) http://siee.olade.org/siee/default.asp- OLADE – SIEE, 2010
(c) UNEP Risø Centre, 2013
(a) CUBAENERGIA, 2012.
(d) OLADE, 2008
(f) PETROCARIBE- Estudio sobre Energías Renovables en El Caribe. Secretaria PETROCARIBE, Diciembre 2007.
(g) World Bank, 2010.
(h) OLADE, 2005. Prospectiva del Sector Energía en los Países de México, América Central y el Caribe

4.2 Methodology followed to determine the mitigation potential in the Caribbean region.

In order to estimate the mitigation potential of grid-connected renewable energy in the Caribbean region, two energy supply scenarios were developed and compared: the reference scenario called BASELINE is based on projected historical trends; and the alternative scenario called MITIGATION is based on GHG emissions mitigation due to scaling up of renewable energy technologies.

The scenarios, as alternative "images" of what could happen, describe the future that could be or could not be, as the evolution is the result of complex dynamic forces which have high levels of uncertainties[32] .

The scenarios were developed for a 20-year period: 2010-2030. This period was divided into one-year periods from 2010 to 2020 (first stage) and then into five-year period from 2020 to 2030 (second stage); with the year 2010 taken as the base year for estimations.

Electricity demand in both scenarios is considered to be equal. In order to meet such a demand, the following aspects are considered:

- BASELINE scenario: follows the current trends in the use of technologies and fuels of each analyzed country.
- MITIGATION Scenario: is based on ensuring greater inclusion of renewables in the energy matrix of each country in line with the potential of renewable energy sources identified in each country, and with their expectations, so that the energy penetration of renewables would constitute about 20% in 2020 and 30% in 2030.

Calculations of the mitigation potential (tonnes of CO_2e) for each GHG mitigation action were performed separately: for each country, for each type of renewable energy introduced, and for a specific period of time. The calculations were performed using the Excel template called "screening.xls" which is based on the "GACMO analysis tool" developed by UNEP Risoe Centre (URC) and the Stockholm Environment Institute (SEI).

The avoided mitigation potential was calculated using unburnt fuel when comparing fuel usage in each of the scenarios. The renewable energy capacities introduced replace an equivalent generating capacity of baseline scenario technologies, which usually are diesel fuel for electricity generation.

The calculation for the Caribbean region was made from the calculations of each country.

To estimate the mitigation potential, the following methodology was applied:

1. Collecting the data for each of the 16 countries in the region.
2. Determining the structure of the energy matrix and of the renewable energy potential identified by sources in the base year, for each country and for the Caribbean region.
3. Defining the BASELINE and MITIGACION scenarios for each country in the region.
4. Calculating the growth of electric power demand for each country and for the Caribbean region for the 2010-2030 periods, based on assumed average annual growth rate for electricity generation capacity.
5. Assessing the needs for new generation capacities in each period, and defining the technology to meet the required capacity in the BASELINE and MITIGATION scenarios for each country and for the region.
6. Determining the renewable energy options and their generating capacity to be introduced in the matrix in line with the renewable potential of the country, considering that the penetration of these options would be 20% in 2020 and 30% in 2030.

[32] AMA, 2009

7. Determining the mitigation potential in the Caribbean region by calculating avoided GHG emissions, equal to the difference between the BASELINE scenario emissions and the MITIGATION scenario emissions, for each period, for each country and for the entire region.

4.3 Collecting the data for the study

The data were collected through an extensive review of international scientific and technical literature.

The main data and analysis used in the study are from the following publications: World Bank[33], PETROCARIBE[34]; NREL and OAS[35]; CUBAENERGÍA[36]; OLADE[37], National Communication to the UNFCCC, Guyana[38] and Belize[39] ; and ENERDATA[40] .

Table 4 shows the electric generation and installed capacity for each country in the base year (2010). Capacity growth rate for each country is also shown in Table 4 for the period considered in this study.

Table 4: Summary of data for electric generation, installed generation capacity and capacity growth rate

No.	Country	Generation (GWh) 2010	Installed Capacity (MW) 2010	Capacity growth rate (%)
1.	Antigua and Barbuda[(a)]	314.6	90.2	3.3
2.	Bahamas	2,195.7	548	3.1
3.	Barbados	1,047.3	239.1	3.5
4.	Belize	7.608	82.9	8.3
5.	Cuba [(b)]	17,395.5	5,852.6	2.5
6.	Dominica	92.9	26.7	2.7
7.	Dominican Republic	15,794.98	3,344	3.4
8.	Grenada	205.819	55.8	5.4
9.	Guyana	765	348.5	3.3
10	Haiti	645.227	338	5.0
11.	Jamaica	5,435.838	854	4.3
12.	Saint Kitts and Nevis [(a)]	232.5	47.4	3.5 y 5.9*
13.	Saint Lucia	380.889	76	3.2
14.	Saint Vincent and the Grenadines	156.464	36	6.9
15.	Surinam	1,634.699	411	2.0
16.	Trinidad and Tobago.	8,331.159	1,544	5.6
Caribbean		54,636.18	13,894.24	

Source: ENERADATA, 2012; (a) World Bank, 2010; (b) CUBAENERGIA, 2012

**Saint Kitts and Nevis were worked each of them as separate islands, and later the results were added*

33 World Bank, 2010
34 Ramírez, 2007
35 OAS, 2011
36 CUBAENERGIA, 2012
37 OLADE, 2005. “Prospectiva del Sector Energía en los Países de México, América Central y el Caribe”. Vol.4.
38 Government of Guyana, 2012
39 Government of Belize, 2011
40 ENERDATA, 2012. http://www.enerdata.net/

Annex 1 shows the structure of the matrix for each country and for the Caribbean region in the base year. The potential of renewable energy by source is shown in Table 3.

4.4 Main results

Annex 1 shows the results of calculations for each country of generation capacity to be incorporated each year of the study period, the generating capacity structure in the BASELINE scenario, the generation capacity structure in the MITIGATION scenario, and the cumulative avoided emissions for each period considered in this study.

The mitigation potential of grid-connected renewable energy for the Caribbean region was determined in line with the aforementioned conditions.

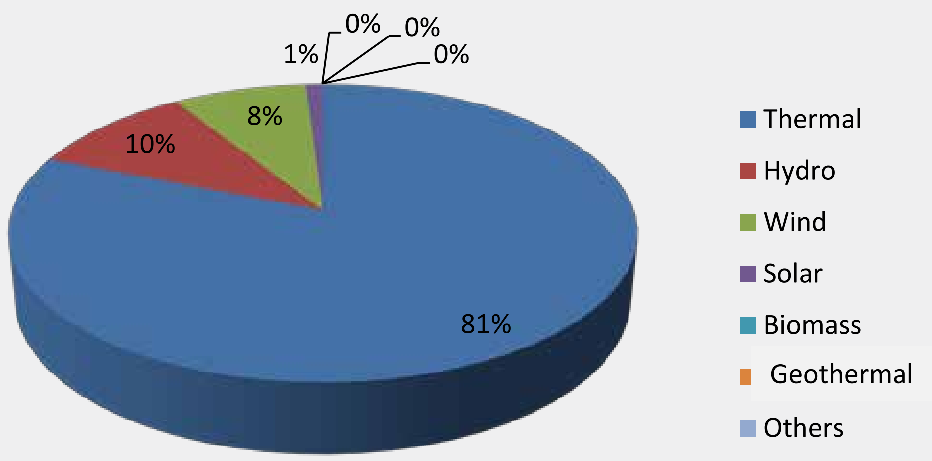
The calculations were made for the two stages defined previously. In the first stage (2010-2020), all calculations were performed for 1-year intervals. In the second stage (2020-2030), all calculations were made for 5-years intervals.

The results in Table 5 show that the Caribbean region requires installing 5,905 MW in the 2010-2020 period, and 8,135 MW in the 2020-2030 period. This means that the Caribbean region will need to double its installed capacity in 2010 by 2030.

Table 6 shows the structure of newly installed generation capacity in the Caribbean countries for the BASELINE and MITIGATION scenarios in the period 2010-2020. In the first stage 2,875 MW of renewables are introduced in the MITIGATION scenario (on a total of 5,905 MW), which represents a 48% increase of renewables compared to the 3.8% observed at the beginning of the period. The penetration of renewables is 19% by 2020.

The structure of the installed capacity by type of technology at the end of the first stage (2020) is shown in Figure 9.

Figure 9: Installed electric power capacity structure in the Caribbean by 2020

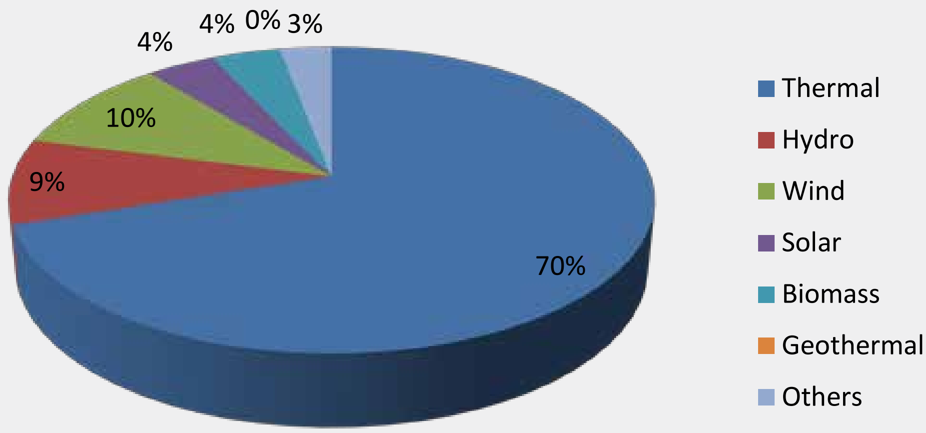


Source: Elaborated by the authors based on ENERDATA, 2013; Cubaenergía, 2012; OLADE, 2012, 2008; OAS, 2011; World Bank, 2010.

Table 7 shows the structure of new generation capacity to be installed in the Caribbean countries for the BASELINE and MITIGATION scenarios in the period 2020-2030. In the second stage 4,661 MW are introduced in the MITIGATION scenario (on a total of 8,135 MW), which represents a 57.3% increase of renewables for the period. The penetration of renewables is 30% by 2030.

The structure of the installed capacities by type of technologies at the end of the second stage (2030) is shown in Figure 10.

Figure 10: Installed electric power capacity structure in the Caribbean by 2030



Source: Elaborated by the authors based on ENERDATA, 2013; Cubaenergía, 2012; OLADE, 2012, 2008; OAS, 2011; World Bank, 2010.

Table 5: New generating capacities required to be installed in the Caribbean in the period 2010-2030

No.	Country	New capacity 2010-2030 (MW)		
		2010-2020	2020-2030	Total
1.	Antigua and Barbuda	35	50	85
2.	Bahamas	200	270	470
3.	Barbados	100	140	240
4.	Belize	80	260	340
5.	Cuba	1,600	2,150	3,750
6.	Dominica	10	10	20
7.	Dominican Republic	1,400	1,800	3,200
8.	Grenada	40	60	100
9.	Guyana	320	380	700
10.	Haiti	220	350	570
11.	Jamaica	500	630	1,130
12.	Saint Kitts and Nevis	30	30	60
13.	Saint Lucia	30	40	70
14.	Saint Vincent and the Grenadines	40	65	105
15.	Suriname	100	100	200
16.	Trinidad and Tobago	1,200	1,800	3,000
Total		5,905	8,135	14,040

Source: Elaborated by the authors.

Table 6: Structure of newly installed generating capacities in the Caribbean by countries for the baseline and mitigation scenarios in the 2010-2020 periods

No.	Country	New capacity 2010-2020 (MW)			
		Total	The BASELINE scenario	The MITIGATION scenario	
				RE	RE penetration 2020 (%)
1.	Antigua and Barbuda	35	DE-100%	30	24
2.	Bahamas	200	DE-100%	100	13
3.	Barbados	100	DE-75%, GT-25%	70	13
4.	Belize	80	DE-57%, H-43%	10	23
5.	Cuba	1,600	TP (fuel and crude)-60%, DE-25%, GTCC-15%	1,000	15
6.	Dominica	10	DE-75%, H-25%	10	28
7.	Dominican Republic	1,400	GTCC-60%, H-10% , TP (fuel oil)-20%, DE-20%	650	24
8.	Grenada	40	DE-100%	20	21
9.	Guyana	320	DE-100%	200	18
10.	Haiti	220	ST-100%	50	18
11.	Jamaica	500	ST-80%, GT-20%	235	21
12.	Saint Kitts and Nevis	30	DE-100%	20	25
13.	Saint Lucia	30	DE-100%	20	19
14.	Saint Vincent and the Grenadines	40	DE-100%	10	24
15.	Suriname	100	H-46%, ST-54%	50	46
16.	Trinidad and Tobago	1,200	ST-100%	400	14
	Caribbean	5,905		2,875	19%

Source: Elaborated by the authors.

DE- Diesel engines, GT- Gas turbine, H-Hydro, TP- Thermal plants, GTCC- Gas Turbine Combined Cycle, ST- Steam turbine. (This is further described for each country in the Annex 1)

Table 7: Structure of newly installed generating capacities in the Caribbean by countries for the base and mitigation scenarios in the 2020-2030 periods

No.	Country	New capacity 2020-2030 (MW)			
		Total	The BASELINE scenario	The MITIGATION scenario	
				RE	RE penetration 2030 (%)
1.	Antigua and Barbuda	50	DE-100%	25	31
2.	Bahamas	270	DE-100%	100	20
3.	Barbados	140	DE-75%, GT-25%	66	20
4.	Belize	260	DE-57%, H-43%	80	29
5.	Cuba	2,150	TP (fuel and crude)-60%, DE-25%, GTCC-15%	1,800	30
6.	Dominica	10	DE-75%, H-25%	10	42
7.	Dominican Republic	1,800	GTCC-60%, H-10% , TP (fuel oil)-20%, DE-20%	1,000	32
8.	Grenada	60	DE-100%	25	29
9.	Guyana	380	DE-100%	160	25
10.	Haiti	350	ST-100%	160	29
11.	Jamaica	630	ST-80%, GT-20%	300	29
12.	Saint Kitts and Nevis	30	DE-100%	10	28
13.	Saint Lucia	40	DE-100%	40	27
14.	Saint Vincent and the Grenadines	65	DE-100%	25	31
15.	Suriname	100	H-46%, ST-54%	60	49
16.	Trinidad and Tobago	1,800	ST-100%	800	29
	Caribbean	8,135	8,135	4,661	30%

Source: Elaborated by the authors.

DE- Diesel engines, GT- Gas turbine, H-Hydro, TP- Thermal plants, GTCC- Gas Turbine Combined Cycle, ST- Steam turbine. (This is further described for each country in the Annex 1)

Table 8 shows the cumulative avoided emissions (calculated as the difference between the BASELINE emissions scenario and the MITIGATION emissions scenario) from 2014, which is the starting year of the implementation of the mitigation actions, to 2030.

This means that the amount of avoided emissions, i.e. the caribbean mitigation potential by 2030, as a result of the scaling/up of renewable energy technologies as described above, is 441 million tons of CO_2e.

If this volume is compared with the 110 million tons of CO_2e emitted in the Caribbean region in 2010, the avoided emissions, as a result of the implemented mitigation actions during 16 years (2014-2030), will be approximately equal to the total of Caribbean GHG emissions of the next four years.

Table 8: Cumulative avoided GHG emissions from 2014 to 2030 (million tCO_2e)

No.	Country	2014	2015	2016	2017	2018	2019	2020	2025	2030
1.	Antigua and Barbuda	0.08	0.08	0.32	0.48	0.65	0.81	0.97	1.95	2.93
2.	Bahamas	0.44	0.87	1.31	1.75	2.18	2.62	3.06	0.15	6.96
3.	Barbados	0.27	0.54	0.95	1.25	1.61	1.96	2.32	5.83	9.34
4.	Belize	0.11	0.16	0.22	0.27	0.27	0.32	0.38	1.99	4.94
5.	Cuba	0.55	1.10	2.60	5.04	8.59	13.24	17.34	69.24	123.88
6.	Dominica	0.05	0.11	0.22	0.32	0.43	0.54	0.65	1.18	1.99
7.	Dominican Republic	1.88	3.77	7.14	11.94	11.94	21.54	26.33	71.86	117.39
8.	Grenada	0.08	0.16	0.27	0.38	0.53	0.69	0.85	2.05	3.69
9.	Guyana	0.48	0.95	1.43	2.38	3.33	4.28	5.23	14.69	24.15
10.	Haiti	0.37	0.98	1.59	2.20	2.81	3.47	4.13	11.55	19.84
11.	Jamaica	0.83	1.66	2.70	3.74	4.78	5.82	6.86	17.10	31.42
12.	Saint Kitts and Nevis	0.11	0.22	0.32	0.43	0.54	0.65	0.75	1.35	1.94
13.	Saint Lucia	0.05	0.10	0.17	0.24	0.34	0.43	0.53	1.94	3.34
14.	Saint Vincent and the Grenadines	0.05	0.16	0.27	0.38	0.48	0.59	0.70	1.78	2.85
15.	Surinam	0.27	0.54	0.27	1.08	1.35	1.62	1.88	4.85	7.81
16.	Trinidad and Tobago	2.15	4.31	6.46	8.62	10.77	12.92	15.08	46.78	78.49
Total avoided emissions (MMtCO_2e)		7.77	15.70	26.23	40.49	50.60	71.50	87.05	254.29	440.98

Source: Elaborated by the authors.

Table 9 shows the mitigation potential by different renewable energy sources: wind, solar, hydro, geothermal and bioenergy.

Table 9: Mitigation potential by renewable energy sources

Source	2020		2030	
	Capacity, MW	MtCO_2e	Capacity, MW	MtCO_2e
Wind	1,660	52.35	793	146.05
Solar	160	3.88	1,913	102.39
Hydro	995	29.07	520	113.08
Geo	20	0.75	85	7.98
Bio	40	1.05	1,350	71.48
Total	2,875	87.1	4,661	441

Source: Elaborated by the authors.

It is interesting to note that until 2020, the main sources which contribute to emissions reduction are wind power, which is an energy source fairly distributed between the different countries of the region, and hydropower that is more specific to some countries such as Cuba, Dominican Republic, Guyana and Belize. After 2020, solar photovoltaic becomes the main contributing source to reduce GHG emissions.

4.5 Conclusions

The Caribbean region has a high potential for renewable energy resources which is 1.76 times the total capacity currently installed.

Based on consumption growth patterns and renewable energy resources potential, a baseline and a mitigation scenario to calculate the mitigation potential of grid-connected renewable energy in each country of the Caribbean region, were identified and estimated. The results show that it is possible to mitigate cumulatively up to 441 million tons of CO_2 by 2030.

In response to the energy needs and in line with the energy policies, the Caribbean set up the objectives of reducing its oil dependence and, diversifying its sources of energy supply using local natural resources, showing a strong commitment to preserve the cultural and natural heritage of this area.

Based on IRENA´s specific cost figures for renewable energy technologies, the investment scenario to scale up the renewable energies by 2030 has been estimated to be USD 21.72 billion[41]. To achieve these objectives will require a major effort from the countries, into developing adequate investment frameworks, policy formulation and promoting technology transfer processes.

Considering the contribution of the mitigation potential of grid-connected renewable energy in the Caribbean region, the financial mechanisms set up under the UNFCCC could play a catalytic role for leveraging additional funds by removing barriers to the use of renewable energy in the region.

41 IRENA, 2012

5. Participation of the Caribbean in mitigation efforts under the framework of the Kyoto Protocol

In order to analyze some potential areas for climate mitigation stemming from the increase of grid-connected renewable energy in the Caribbean, it would be advantageous to analyze the situation based on the participation of Caribbean countries in recognized mitigation actions arising from the UNFCCC.

The Clean Development Mechanism (CDM) has been one of the flexibility mechanisms of the Kyoto Protocol through which mitigation actions at project level have managed to reach international carbon markets. By the end of 2012 the first commitment period of the Kyoto Protocol had concluded, therefore it is a good starting point to assess the participation of the Caribbean region in CDM.

Table 10 shows the status of participation of the countries in relation to the Kyoto Protocol.

Table 10: Status of ratification and existence of CDM Designated National Authorities

Country	Signature of Kyoto-Protocol/ Ratification Acceptance	Registered CDM Designated National Authority to the UNFCCC
Antigua and Barbuda	Yes (16/03/98)	Yes
Bahamas	Yes (9/04/99)	Yes
Barbados	Yes (7/08/00)	Yes
Belize	Yes (26/09/03)	Yes
Cuba	Yes (15/03/99)	Yes
Dominica	Yes (25/01/05)	No
Dominican Republic	Yes (12/02/02)	Yes
Grenada	Yes (6/08/02)	Yes
Guyana	Yes (5/09/03)	Yes
Haiti	Yes (6/07/03)	Yes
Jamaica	Yes (6/07/03)	Yes
Saint Kitts and Nevis	Yes (8/04/08)	No
Saint Lucia	Yes (16/03/98)	Yes
Saint Vincent and the Grenadines	Yes (19/03/98)	No
Surinam	Yes (25/09/06)	Yes
Trinidad and Tobago	Yes (7/01/99)	Yes

Source: UNFCCC, 2013

The majority of the Caribbean countries signed and ratified the Kyoto Protocol long before the KP entered into force in 2005, which is evidence of an early interest in the Protocol.

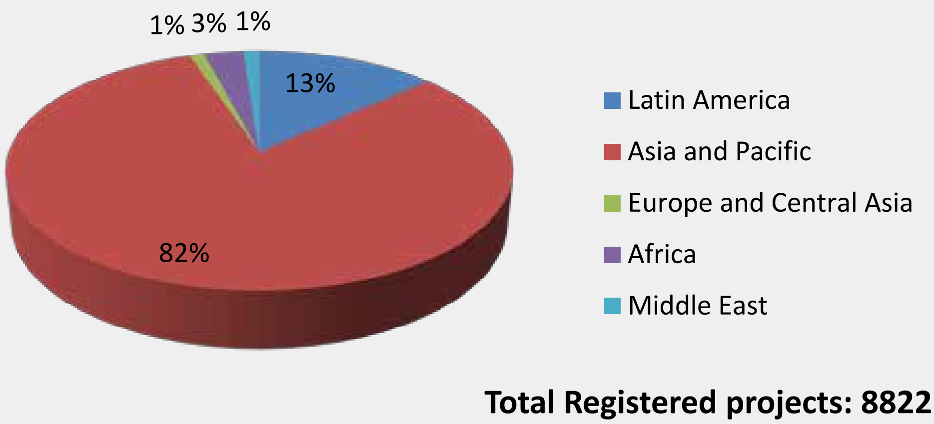
Most of the Caribbean countries with the exception of three have duly appointed a CDM Designated National Authority to the UNFCCC. This was also a clear signal of the existing interest in the region to fully participate in the CDM and host the CDM projects in their countries.

5.1 Participation of the region in traditional CDM projects

Latin America and the Caribbean region have played an important role in the early historical development of CDM, since the beginning of the mechanism, a very dynamic region with a great and early development. Once the system was derived from CDM modalities and procedures, and structured appropriately to include issues such as market size, volumes offered reductions, etc., it was clear that Asia, and in particular, China and India, had played leading roles in the development of CDM projects.

Using statistics from the UNEP Risoe Centre CDM Pipeline[42], Figure 11 shows the distribution of CDM projects (not including rejected and withdrawn projects) by region up to November 2013. As it is observed, Latin America and the Caribbean are in second place, after Asia and the Pacific, with 13% of all projects.

Figure 11: Distribution of CDM projects by geographic region



Source: UNEP Risoe Centre, 2013b (November)

The global statistics for the Latin American region do not reflect the existing reality of the Caribbean region.

The Caribbean region has only 26 projects in the CDM project cycle, representing a value of only 2.2% of the overall projects of Latin America and about 0.3% of all CDM projects worldwide.

Only six countries out of the 16 included in this study, have submitted 26 CDM projects. Of these 26 projects, 19 are from Dominican Republic, two from Cuba, two from Jamaica, one from Guyana, one from Belize and one from Bahamas. Among the 26 projects, only 20 have been registered and only four of them are issuing CERs.

Of the 26 Caribbean projects, 18 are renewable, representing 67%, two correspond to landfill, gas and three to energy efficiency from the supply side, representing 11% each, two to fossil fuel switch representing 7% and one dealing with cement.

In the case of renewable projects, nine correspond to wind, six to biomass, two to solar and one to hydropower.

The 26 projects from the Caribbean represent a total capacity of 851.57 MW and report to their PDD investments a sum exceeding USD 1.1 billion.

One would expect most of the projects in the Caribbean region to be small scale, however only eight of the 26 Caribbean projects classify as small and only five of them have been registered.

At present, the list of projects registered as CDM projects in the Caribbean, includes those included in Table 11.

[42] UNEP Risoe Centre, 2013b

Table 11: CDM projects registered by Caribbean countries

Date of Registration	Project name	Estimated annual emissions reductions (tCO2)
Dominican Republic		
20 Oct 06	http://cdm.unfccc.int/Projects/DB/AENOR1153378528.03/view	12,3916
09 Apr 10	Bionersis project on La Duquesa Landfill, Dominican Republic	359,810
28 Nov 11	Matafongo Wind Farm	70,275
29 Mar 12	Quilvio Cabrera Wind Farm Project	10,937
01 Jun 12	CEMEX Dominicana: Alternative fuels and biomass project at San Pedro Cement Plant	99,797
06 Aug 12	Textile Offshore Site Dominicana Biomass Residues Cogeneration Project (TOS-2RIOS)	35,738
27 Aug 12	Los Cocos Wind Farm Project	54,183
23 Mar 12	Los Cocos II Wind Farm Project	112,489
14 Sep 12	Steam Generation Using Biomass	48,050
12 Oct 12	Palomino Hydropower Project in the Province of San Juan de la Maguana in the Dominican Republic	119,598
17 Oct 12	Solar PV Project in Dominican Republic	35,375
27 Oct 12	Granadillos Wind Farm	69,657
03 Dec 12	30MW Solar PV - Monte Plata	29,254
30 Dec 12	http://cdm.unfccc.int/Projects/DB/BVQI1356871523.36/view	29,968
	Cuba	
22 Jun 07	Energas Varadero Conversion from Open Cycle to Combined Cycle Project	342,235
27 Feb 09	Methane capture and destruction on Calle 100 landfill in Havana and Gascon landfill in Cuba. Bundle CDM project	123,162
	Jamaica	
19 March 06	http://cdm.unfccc.int/Projects/DB/DNV-CUK1137055328.94/view	52,540
21 Dec 11	http://cdm.unfccc.int/Projects/DB/SGS-UKL1323883065.28/view	40,348
	Guyana	
04 May 08	http://cdm.unfccc.int/Projects/DB/SGS-UKL1196357091.25/view	44,733
	Bahamas	
03 Jul 12	http://cdm.unfccc.int/Projects/DB/RINA1325006921.15/view	24,877

Source: UNEP Risoe Centre, 2013b (November)

Even though the projects are few in number and the majority are large scale projects for CDM, it is appropriate to mention that being consistent, developers of renewable energy projects sought in CDM an alternative to the monetization of emissions reductions. However, during the first compliance period it is comparatively noticeable that there have been relatively few development activities on renewable energy projects in the Caribbean region.

OLADE[43], in a recent study conducted in Jamaica, detected that a good number of renewable energy projects as well as other projects in relevant sectors failed to be implemented for various reasons inherent to the CDM lifecycle and the local environment for project development.

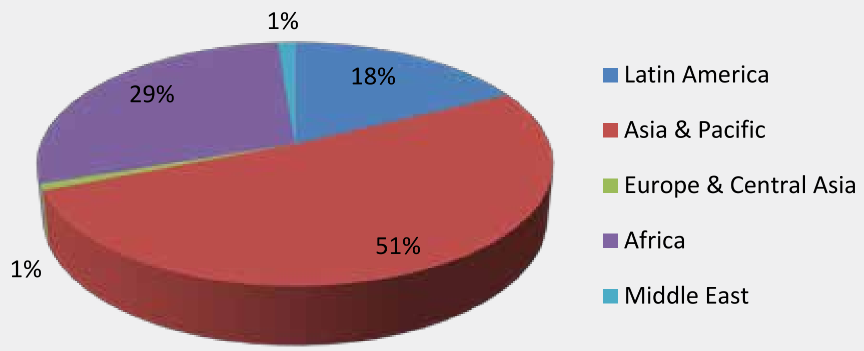
5.2 Participation of the region in the Programmatic CDM

The Programmatic CDM, based on Programme of Activities or PoA is the result of efforts to reduce transaction costs in CDM and to widen the application of the mechanism to small project activities.

The PoA offer advantages over the approach of traditional CDM projects, such as reducing transaction costs for project activity. Furthermore, it is not necessary to define the magnitude and location of each CPA a priori, reducing the risk of funding project activities, when the PoA is already registered. Finally it is a mechanism to facilitate regional programs.

In the UNEP Risoe Centre's PoA Pipeline, there is a total of 441 PoA submitted worldwide. The distribution of PoA by region is shown in Figure 12. It is also worthwhile mentioning that there are two interregional programs.

Figure 12: Programme of Activities by geographic region



Total registered PoAs: 232

Source: UNEP Risoe Centre, 2013b

In Latin America and the Caribbean there are 62 PoAs, and 41 of them are registered, the rest is in the process of validation or request for registration.

As of November 2013, according to the UNEP Risoe Centre PoA Pipeline[44] , there were about 227 PoAs, related to the use of renewable energies (see Table 12). Out of these, about 118 had already completed the registration process.

[43] OLADE, 2013
[44] UNEP Risoe Centre, 2013b

Table 12: Registered PoAs in the UNEP Risoe Centre's pipeline (November 2013)

Sector	PoAs	PoAs%
EE demand side	123	31.9%
Waste	78	20.2%
Solar	71	18.4%
Hydro	39	10.1%
Wind	24	6.2%
Biomass energy	15	3.9%
EE supply side	10	2.6%
Coal Mine Methane	5	1.3%
Transport	7	1.8%
Fossil fuel switch	5	1.3%
Forestry & Agriculture	5	1.3%
Fugitive	3	0.8%
Geothermal	1	0.3%
Industrial gases	0	0%
Total PoAs	386	100.0%

Source: UNEP Risoe Centre, 2013b

The Pipeline showed 66 multi-countries PoA, most of them in the African region.

At the Conference of the Parties of the UNFCCC held in December 2012 in Doha, the second commitment period of the Kyoto Protocol was approved, which needs to be ratified by the Parties. Consequently, CDM remains valid as a flexibility mechanism in the Protocol, being the only operating mechanism until the adoption of a new climate regime to be agreed upon by the Parties in 2015.

Although Programs of Activities (PoAs) were institutionalized in the CDM in order to create a vehicle to integrate emission reduction project activities types associated to small scale interventions with small amounts of emissions reductions each (characteristic of many renewable energy technologies in small power markets); and that in other areas of the world, especially towards the end of 2012, success had being achieved in registering these types of programs; the Caribbean Region has only submitted two Programme of Activities (PoA) under the CDM. The first one is the Petrotrin Oil Fields Associated Gas Recovery and Utilization PoA[45] which is registered and the other one is the Replacement of Traditional Charcoal Stoves with Efficient EchoRecho Stoves in Haiti[46] which is currently requesting registration in the CDM.

[45] http://cdm.unfccc.int/ProgrammeOfActivities/poa_db/VOJCMND3RBQ0I692KWH8YPT4ESGFZ1/view
[46] http://cdm.unfccc.int/ProgrammeOfActivities/poa_db/45N2WHPB9DJYUFTELKR8ZIC7OQSAM6/view

PoAs, have so far failed to be instituted as dissemination vehicles for small scale project activities in the Caribbean region although there is a clear potential for such schemes, especially as the region commits to large scaling-up efforts for renewable energy deployment. Experience elsewhere, during the CDM First Commitment Period has indicated that PoAs were a sound way to integrate small scale projects and emissions reductions and bringing them into the attention of carbon buyers; especially those now associated to the interest of some specific countries such as the European Union members as well as other emerging countries establishing transitional CERs purchasing facilities.

Moreover, PoAs development approaches are gaining acceptance as interesting and appropriate platforms for the structuring of Nationally Appropriate Mitigation Activities (NAMAs) as part of the emerging context of new climate finance mechanisms for mitigation internationally, since monitoring and other aspects associated to programs involving renewable energies are well represented and understood from their carbon and mitigation components.

5.3 Conclusions

As a result of the work carried out during the implementation of ACP-MEAs project in the Caribbean region, a series of appropriate conclusions regarding the situation of the Caribbean participation during the first period of compliance of the Kyoto Protocol in CDM can be drawn:

- Various mitigation efforts in the region were not formulated within the context of CDM, as they were initiated during the transition period before the ratification of the protocol i.e. at the beginning of CDM. At this time conditions were not suitable for their preparation and approval of CDM regulatory bodies.
- Taking into account the implicit inherent barriers of CDM in relation to regulatory complexity, time and transaction costs, many abandoned the monitoring of CDM projects in the formulation and registration stages. This was partly intensified by the various development barriers in the region for renewable energy projects by national regulatory authorities in most countries.
- The number and location of projects in the Caribbean CDM portfolio clearly shows the asymmetries between countries. These partially reflect the economic situation, the sectoral scales, the existence of and capacity of response of institutions for promotion and approval, and their policy frameworks for the adoption of renewable energy.
- Contrary to expectations regarding the expected size of most of the projects, large-scale CDM projects were represented in the regional portfolio.
- The PoA failed to be instituted as a dissemination vehicle of mitigation in project activities in the Caribbean region.

The lessons learned from the participation in CDM should be taken into account to evaluate how mitigation efforts could or should not be supported by escalating ascription of renewables in the Caribbean region. In addition, one should also consider institutional aspects of responsiveness, removal of existing barriers to renewable energy and the characterization of absorption capacity projects in order to outline an adequate roadmap that would support mitigation efforts from its national and regional electric sector.

6. Assessment of Programme of Activities cases for scaling up renewable energy in the Caribbean

6.1. Mitigation potential by renewable energy sources in the region.

Chapter 2 has shown the mitigation potential of grid-connected renewable energy in the Caribbean region until 2030. The global mitigation potential calculated for the region is 441 million tons of CO_2e. Table 9 shows that the largest potential sources in terms of contribution to installed capacity and emission reduction potential are the following:

- Wind Energy with 32% of new installed power with an estimated total of 2,450 MW and 146.5 million ton CO_2 of approximate reductions;
- Solar PV with 27.5% of new installed power with a total of 2,070 MW and associated reductions of 102.4 million ton CO_2;
- Hydropower with 20% of newly installed power with a total of 1,515 MW and associated reductions of 113 million ton CO_2;
- Bioenergy with 19% of new installed capacity totaling 1,390 MW and associated reductions of 71.48 million ton CO_2; and
- Geothermal Power with 1.5% of newly installed capacity, totaling 100 MW and associated emission reductions of 7.98 million ton CO_2.

In order to analyze the scaling up of different renewable energy sources in the region and to focus on the possible programmatic actions which could attract climate funding to support the dissemination of renewable energy in the Caribbean, an assessment of different technological sectors was made.

The list of the criteria used in the assessment is presented below.

1. Availability of information on the technologies.
2. Availability of National or regional studies on targeted technologies.
3. Technical assessments of the potential for renewable energy technologies that are available in the region.
4. Available policies for renewable energy penetration for a specific period.
5. Definition of future investment projects related to renewable energy technologies.
6. Basic data available to estimate the mitigation potential for each renewable energy technology.
7. Existing development policies for the energy sector relevant to the renewable technologies.
8. Existing CDM projects or PoAs with their corresponding approved methodologies for the renewable technologies (at least in contexts similar to those of the Caribbean).

Taking into account the prerequisites shown in Annex 2, the following renewable energy technologies were considered of interest for developing programmatic approaches:

1. Wind power generation;
2. Photovoltaic power generation;
3. Power generation from landfill gas;
4. Power generation from biomass residues;
5. Hydropower generation;
6. Power generation from agricultural residues especially pig manure,
7. Geothermal generation; and
8. Power generation from biofuels.

In order to make a detailed analysis of programmatic actions for scaling up renewable energy, the cases of wind energy and biogas production from swine manure were selected:

- The rationale for the selection of wind energy is based on the high number of wind-related activities identified in the region, where the potential for this resource is high, and taking into consideration that over the first few years towards the implementation of scaling up plans for renewable energy, it is likely that wind energy will play an important role in capacity additions in the region.

- The potential of biogas from pig manure was identified for Cuba and Dominican Republic under the Carbono 2012 project. In addition, the study identified potential synergies within the two countries and established a set of environmental criteria to assess the potential environmental impacts arising from these activities.

6.2. The case of interconnected wind generation in the Caribbean

Wind energy is one of the renewable energy applications with highest additional capacity potential in the world. In the last years, these types of generating plants have experienced a quick development (REN 21[47]):

- In 2011, nearly 40 GW of wind capacity was installed to reach a total of 238 GW installed worldwide.
- The cumulative average annual growth rate 26% between 2006 and 2010.
- In 2011 Latin America had the highest growth rate worldwide.

This reflects that in the Latin American region a substantial base of technical and financial services for supporting wind generation is currently developed.

At international level, wind technology prices are very competitive in sites where wind resources are good, as well as in terms of leveled generation costs as shown in Table 13.

Table 13: Costs and returns for wind generation in 2010

	Installed cost (2010 USD/kW)	Capacity factor (%)	Operations and maintenance (USD/kWh)	LCOE* (USD/kWh)
Onshore				
China/India	1,300 to 1,450	20 to 30	n.a.	0.06 to 0.11
Europe	1,850 to 2,100	25 to 35	0.013 to 0.025	0.08 to 0.14
North America	2,000 to 2,200	30 to 45	0.05 to 0.015	0.07 to 0.11
Offshore				
Europe	4,000 to 4,500	40 to 50	0.027 to 0.048	0.14 to 0.19

*Source: IRENA, 2012, *Assumes a 10% cost of capital*

The levelized cost of energy (LCOE) is the price required in a project so that the revenues are equal to the costs including a return margin of invested capital equal to the discount rate or capital cost.

The values shown in the table above are indicative and cannot be generalized. These values will change according to the project size, location, etc.

At the Caribbean level, recent calculations made by the World Watch Institute (cited above) in the case of Jamaica indicate that the levelized cost of energy would be about 10 cents / kWh. This price is very competitive compared to the cost of diesel generation in Jamaica which is about 25 cents / kWh.

As mentioned above, wind generation capacity in the Caribbean should be around 2,453 MW

[47] REN 21. Renewables 2012: Global Status Report. www.ren21.net

by 2030. This would contribute to GHG emissions reduction by 146 million tCO_2 compared with the baseline scenario.

Wind resource assessment for power generation is currently underway in many Caribbean countries. Generation projects are found in small countries in the Eastern Caribbean and also in Dominican Republic and Cuba.

Table 14 shows the development of wind farms in English-speaking Caribbean islands.

Table 14: Current status of wind power in some Caribbean countries

Country	Project	Level of preparation	Potential developer	Remarks
St. Lucía	15 MW @ Sugar Mill, approx 15,000 t/CO_2	Pre- Feasibility	LUCELEC	Land issue pending
SVG	7 MW @ Ribishi Point	Tender-ready	VINLEC	First tender unsuccessful
Barbados	10 MW @ Lamberts	FS, EIA, Financing	BL&P	Acceptance, land issues
Grenada	6-10 MW, 3 potential sites	Wind speed measurements	GRENLEC	Land negotiation failed
Jamaica	18 MW @ Wigton II, 4 MW @ Monroe	In operation	WWF Ltd., and JPS	WWF operates Wigton I with 20 MW since 2004
Dominica	3-6 MW	In preparation	DOMLEC	Site identification ongoing
Antigua & Barbuda	Not decided yet	Wind measurement since 2010	APUA	Site identification ongoing
Suriname	2 wind sites identified	Wind measurement since 2009	IPPs, pending	Wind data analysis pending
Trinidad	Wind power on N/NE coast	Request for TA pending	pending	New request, needs screening
Nevis	2.2 MW Wind farm @ Madden´s Estate	Commissioned in Sept. 2010	Wind watt Ltd. (IPP)	First Wind farm in OECS

Source: Dipl.-Ing. Benjamin Jargstorf. Wind Power in the Caribbean: ongoing and planned projects 2011. Factor 4 Energy Projects GMBH. Produced for CARIBBEAN RENEWABLE ENERGY DEVELOPMENT PROGRAMME, GIZ/CARICOM. St. Lucia, May 2011.

In Cuba, the Las Tunas Utility Co. is developing a 50 MW wind farm with an estimated electricity generation of 150 GWh/year. The farm will start operating by 2015[48]. Cuba has a high wind potential of 1,257- 3,520 MW with capacity factor of 25%[49].

[48] BNamericas, 2012
[49] Santamarta Flórez, 2013

Table 15: Estimated wind generating capacity potential in Cuba

Provinces	Area km²	Area km²	Wind potential MW	Equivalent potential CF=25%, MW
Pinar del Río	34	7	35- 98	8- 24
La Habana	65	13	65- 182	16- 45
Ciudad de la Habana	13	3	15- 42	3- 9
Matanzas	21	4.2	3- 8	5- 15
Villa Clara	0.1	0.02	0.1- 0.28	0.02- 0.07
Cienfuegos	0	0	0	0
Sancti Spíritus	0,2	0.04	0.2-0.6	0.05- 0.14
Ciego de Ávila	110	22	110- 308	27- 77
Camagüey	313	63	315- 882	78- 219
Las Tunas	25	5	25- 70	6- 17
Holguín	766	153	176- 2,142	191- 536
Granma	1,184	237	1,185-3,318	296- 828
Santiago de Cuba	734	147	735- 2,058	183- 514
Guantánamo	1,555	311	1,555- 4,354	389- 1,089
Isla de la Juventud	210	42	210-588	52- 147
Total	5,030	1,006	5,030- 14,084	1,257- 3,521

Source:http://santamarta-florez.blogspot.com.es/2013/05/cuba-will-show-its-progress-in-world.html#!/2013/05/cuba-will-show-its-progress-in-world.html

In Dominican Republic, wind farms are operated in the country for a combined capacity of 77 MW. The recent studies made on wind resource availability in Dominican Republic and the concessions granted by the electrical national regulatory body show that there is a high interest in developing this technology. Resource assessments indicate outstanding wind regimes in some areas of the country. Assessments recently published by the World Watch Institute[50] indicate that there are good wind regimes for both average speeds and capacity factors. The largest potential is in the provinces of Pedernales, Monte Cristi and Bani.

Achieving the scaling-up of wind power in the Caribbean region will require a technical and financial effort by the countries during the next few years. Therefore it is important to assess the financial support needed by climate funding.

There are many CDM Programme of Activities implemented in the field of wind energy in countries outside the Caribbean region. Nevertheless there is no multi-PoA implemented.

A wind energy PoA could be analyzed based on the elements shown in Table 16.

[50] http://www.worldwatch.org/sustainable-energy-roadmaps

Table 16: Elements for the assessment of the PoA: "Wind program in the Caribbean"

Geographic Coverage	Emissions Reduction Potential	Impact of carbon finance in facilitating project development	Sustainable Development Benefits	Ease of implementation: national, regional, EC in the region
The coverage of a PoA could include the Caribbean as defined in this study or it might include some of the countries in which there are a more suitable weather conditions for wind projects. The PoA can be geographically matched taking the absorptive capacity of wind power and considering the development of pilot projects, initially in some countries and then extending their coverage. Multi-country PoAs provide a clear regulatory space for the integration of objectives to develop mitigation actions, since other areas of climate funds are restricted to national actions.	The emission reduction potential by 2030, which is the period of time considered in this study, is 146 $MtCO_2$. However, only few concrete projects are identified in the region. To develop a PoA in this field will require a strong action on regulatory issues as well as mobilizing investment funds (debt and in equity). It is important to take into account that it presupposes a greater interconnected scaling-up for these projects. This has only been observed in countries such as China and India that attracted major investments during the first commitment period of the Kyoto Protocol. The potential estimated in this study may differ from that estimated with CDM methodologies. Due to it has been estimated from the substitution of fuel energy equivalent avoided vs. the estimate based on a combined margin of the grid.	The impact of carbon finance is difficult to determine due to the significant carbon price decrease observed on the markets (loss of up to 90% of CERs price in 2012). In 2011 carbon could represent up to 1-1.5% increase in the project return. Currently carbon only represents 0.1-0.2% increase in the project return. Given that the CDM transaction costs remain high, incentives to develop CDM projects are low. Nevertheless, new concepts such as NAMAs could allow attracting some catalytic resources to remove barriers for wind energy management in the Caribbean.	From the Caribbean perspective and with the current situation, a programme of this kind would generate a valuable contributions to sustainable development	At CDM regulatory level there are PoA experiences of Managing Entity in the wind energy generation as well as in the integration of intermittent distributed generation of renewable energy. The Caribbean can take advantage of "fast track" additionality spaces, modalities and procedures in countries with few projects approved; it may seek approval of standardized baselines, and propose automatic additionalities as per concept of positive lines of generation technologies. There are some current projects in development that could be used as model to conceptualize a PoA as well as to develop the required CDM documentation. One of the most significant barriers is: Determining model of integrated business management for such intervention. The most important requirements to achieve the scaling up of wind energy seem to be focused on regulatory issues as well as on investment management capabilities in both debt and equity capital. Regulatory issues refer to modeling contractual issues, opportunities for participation and existence of "fuel surcharges" which is part of the operation of electric utilities.

Source: Elaborated by the authors.

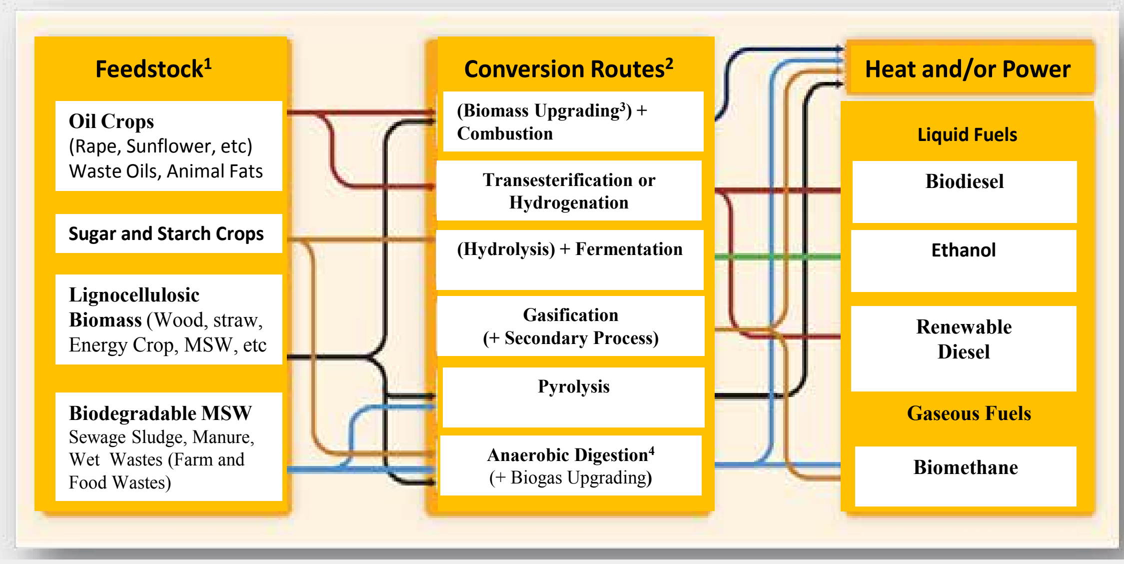
6.3. The case of mitigation by distributed generation using biogas from swine manure in Dominican Republic and Cuba

The Global Methane Initiative (GMI) conducted a study, which concluded that pig farms have

the greatest potential for methane emission reductions in the agricultural and livestock sectors in Dominican Republic[51].

The technology for power conversion from swine manure management is well known. Its dissemination is closely linked to regulatory issues as well as to the availability of the technology at a small scale tailored to the farms or animal management facilities. Figure 13 shows the chain of the technological pathways for this type of bioenergy.

Figure 13: Current trends in bioenergy conversion pathways



Source: REN 21, 2012

Methane is generated by an anaerobic process (without oxygen) of organic matter degradation. This anaerobic digestion (AD) can be controlled in an anaerobic reactor or digester. There are several AD technologies that can be implemented in pig farms, such as covered anaerobic lagoons, complete mix digesters, plug flow reactors, and up-flow reactors for small farms: bags digesters, floating bell digesters and digesters of the Chinese type.

The main factors to be considered in choosing a type of digester include total solids concentration, temperature, the area available for the digester, and the level of complexity of operation and maintenance. Cost is obviously a factor, but plays only a significant role when more than one anaerobic digestion technology is appropriate for a specific project.

The reduction of greenhouse gas emissions is reached by two ways: the combustion of biogas in a flame, resulting in CO_2 and H_2O production with a greenhouse effect less than that produced by the direct emission of methane to the atmosphere; and the use of the biogas as a fuel substituting other conventional fuels.

Anaerobic treatment provides additional benefits like the production of organic fertilizers and the possibility to achieve levels of cleaning water in a controlled manner to facilitate its reuse.

Finally, methane can be used in an engine-generator to generate electricity.

Although the use of anaerobic digesters is not a new issue in the sector, their useis not a common practice in Cuba and in Dominican Republic.

[51] GMI, 2011

Under the regional project Carbono 2012, “Promoting the Adaptation and Mitigation to Climate Change, Energy and Environment”, UNDP conducted a feasibility study for the development of a CDM PoA for the capture and use of methane in pig farm sector in Dominican Republic (CUBAENERGIA, 2012).

Similarly, in Cuba, under the Carbono 2012 project and in collaboration with the international project “Capacity Building for the Implementation of Clean Development Mechanism in Cuba”, a study on opportunities for the development of a CDM PoA for the capture and use of methane in pig farms in Cuba has been conducted (CUBAENERGIA, 2012).

Exploring the synergies as a result of implementation of these projects in Cuba and Dominic Republic has provided important data showing the possibility of scaling-up a PoA on distributed generation from swine manure management.

Many CDM PoAs have been registered internationally in the field of swine manure waste management. Nevertheless, the general objective has been to avoid methane release into the atmosphere and not the distributed electricity generation.

A PoA in the field of pig manure waste management could be analyzed based on the elements shown in Table 17.

Copyright: Iván Relova

Table 17: Elements for the assessment of PoA: "Distributed generation by pig manure management in Dominican Republic and Cuba"

Geographic Coverage	Emissions Reduction Potential	Impact of carbon finance in facilitating project development	Benefits for sustainable development	Ease of implementation: national, regional, EC in the region
The geographic coverage of a PoA in this field should be the area of each country, recommending structuring two PoAs at national level	In Dominican Republic, the analysis of the pig farm sector shows a total potential of methane emission reductions of 241.80 tCO_2e. This value could increase to 349,50 tCO_2e by 2018, and up to 657 tCO_2e by the end of 2030. It is estimated that it would be possible to experience a potential gain of up to 20% of potential by using methane avoidance projects. The aim should focus on generating a cluster of pig farm enterprises in the Cibao region, where there is a little more than 300 large pig farms. . An initial segmentation, should initially consider the enterprises with more than 400 female swine breeding sows, would ensure that the changes are economically attractive. In Cubait should be considered the pig feedlots production in the state sector with 500 000 pigs. The biogas produced through an appropriate swine manure treatment would allow to reduce 183, 000 tCO_2e emissions within five years.	The impact of carbon finance is difficult to assess due to the significant decrease of the carbon prices observed in the carbon markets (high volatility) (the CERs price has decreased up to 90% in 2012). However, it is assumed that the carbon impact could be representative depending on the technological evaluation performed to be conducted during the feasibility study.	Undoubtedly sustainable development benefits are high in this type of intervention as they have a high impact on a local environment al issue and not just on the level. In addition they contribute at global level reducing GHG emissions.	The results of the survey conducted for this study indicates clearly that there are interested institutional players which could play the CDM PoA Managing Entity role. There are international experiences in the development of biogas programs that reduce the formulation and regulatory risks. However, the most important barrier is related to the appropriate development of technology packages at country level. In addition regulatory elements could facilitate or not the acceptance of new type of renewable energy generation into the energy grid systems. The emission reductions (CERs) have become a significant risk for any PoA. Especially for those PoA which its financial closure relies on the CERs prices. In some cases it will be difficult to reach financial outcome and therefore to attract private investors. In Dominican Republic, there are two legislative tools that affect the development of anaerobic digestion systems in pig farms: - The Environmental Standard for Water Quality and Discharge Control, which does not establish specifically the maximum discharge permissible values for pig farms, but that must be taken into account to comply with good practices and prevent soil and water pollution of freshwater bodies. - The Law on Incentives for the Development of Renewable Energy Sources, which gives a release of 100% import tax on equipment for generating electricity from renewable energy sources. This law also establishes that Utility Companies will have to purchase surplus electricity from renewable sources, as well as determine the sale price of different types of renewable energy in Dominican Republic.

Source: Elaborated by the authors.

The development of a PoA in the field of swine manure waste management in Cuba or Dominican Republic seems to be attractive from many perspectives. The sector has a has a very interested actors actors very interested in the monetization of its emission reductions to achieve the dissemination of environmentally sound management technologies. Using swine manure, to solve a very important local environmental problem produced by the mismanagement of the swine manure. It seems that the viability of this type of PoA relies on the development and demonstration of technology packages that are not commercial available in any country and on the approval of regulatory policies for managing distributed generation. The PoA could begins with a concentration of captive generation of this type of pig farms.

6.4. Conclusions

Two cases of potential development of PoAs to increase the renewable energy share in the Caribbean have been described and analysed.

Both cases raise very different perspectives regarding the contribution of renewable energy but are consistent with the energy and climate change policies promoted by the Caribbean countries at national and regional levels.

PoA could be an interesting tool to monetize emissions reductions. However, the current behaviour of the carbon markets does not generates an attractive framework for national and international actors to invest on CDM PoAs as the return of monetization will likely not occur in the short term. This could change, according to new trends or agreements to be taken by the Party countries within the UNFCCC or UN frameworks.

The two PoAs rwill require to establish important partnerships which could generate solid financial schemes which attract private investors either in wind energy generation and in the livestock and agribusiness sectors. However these partnerships have not been established yet.

Different types of barriers have been identified and those need to be removed to allow the scaling up of cleaner technologies. This include technological barriers, in absorption capacity, nature of renewable generation potential, market and regulations barriers, and financial and promotion barriers.

It looks to be a good moment to promote a healthy discussion among the Caribbean countries on the role of climate funding to remove barriers in order to implement climate mitigation actions. The Caribbean region cannot be left behind in mobilizing resources through the new international mechanisms such as NAMAs.

Nevertheless these efforts should be consistent with the regional and country objectives, and complement the existing strategies for mobilizing actors, policies and funding.

7. Conclusions and Recommendations

The Caribbean Countries are “heavily dependent on imported petroleum products, largely for transport and electricity generation. This is likely to continue in the short to medium term; however the efficiency of such use can be greatly increased through appropriate technology and national energy policies which promote a more economic and environmentally beneficial use of energy. Several constraints to the large-scale commercial use of renewable energy resources remain, including technology development, investment costs, available indigenous skills and management capabilities. In this context, the electricity generation based on thermal fossil fuel based sources is in the order of 93.2% with renewable energy sources amounting to a mere 6.8% of total installed capacity (mainly from hydro resources in selected countries).

About 98% of GHG emissions in the Caribbean come from CO_2 in different sectors; energy representing about 82% of such emissions. Emissions from the energy sector in the region have scaled up over the last 20 years. Therefore carbon emission reduction opportunities in the sector should play an important role in any road map for development of climate change mitigation strategies at the regional as well as in-country level. Moreover emissions reductions from scaling up renewable energy technologies in the region need to be a central part of overall low carbon development paths.

A baseline and a mitigation scenario have been developed in order to assess emissions reductions from scaling up renewable energy technologies. The baseline scenario describes a “business as usual” approach simulating future emissions due to the continuation of observed capacity addition practices observed in the region and in specific countries. The mitigation scenario takes into consideration capacity expansion needs and simulates renewable energy target penetration in the order of 20% and 30% for 2020 and 2030 respectively for total electricity generation. The quantitative assessment of mitigation potential (tons of CO_2) was performed separately for each country. The calculation of the avoided mitigation potential is made based on un-burnt fuel displaced by the introduction of renewable energy generation (which is consistent with National Greenhouse Inventory practices). The accumulated emissions reduction mitigation to be achieved from the targeted renewable energy contribution analyzed is of 440.98 million ton CO_2 by the year 2030. The top 4 countries in terms of potential total quantity of emissions reductions (Cuba, Dominican Republic, Trinidad and Tobago, and Jamaica) account for nearly 80% of the potential mitigation in the region, although the benefits from the scaling up of energy diversification reach down to all the countries.

The region-wide specific participation envisaged by Renewable Energy Technologies and their associated emissions reductions by 2030 indicate that:

- Wind Energy with 32% of new installed power with an estimated total of 2,450 MW and 146.5 million ton CO_2 of approximate reductions;
- Solar PV with 27.5% of new installed power with a total of 2,070 MW and associated reductions of 102.4 million ton CO_2;
- Hydropower with 20% of newly installed power with a total of 1,515 MW and associated reductions of 113 million ton CO_2;
- Bioenergy with 19% of new installed capacity totalling 1,390 MW and associated reductions of 71.48 million ton CO_2; and
- Geothermal Power with 1.5% of newly installed capacity, totalling 100 MW and associated emission reductions of 7.98 million ton CO_2.

The Caribbean region did not entirely take the opportunity to participate in the Clean Development Mechanism mainly due to a non-adequate institutional framework and lack of proper incentives to attract foreign private investment. Until November 2013, the Caribbean Region had only 26 projects (coming from 6 countries) that had entered into the pipeline of the Clean Development Mechanism (CDM), with 18 of those projects having being successfully registered in the mechanism and only 4 having issued CERs.

Several reasons may explain the low uptake of renewable energy projects within the CDM in the region. Some of those reasons are within the realm of how renewable energy projects are developed in the area while others may be related to the CDM itself and its institutional/market frameworks. On the project development side, the energy sector in many of the countries has a very complex institutional/political setup, coupled to cumbersome regulatory and approval processes. Therefore project development activities take time and are frequently delayed by clearing all the barriers and hurdles that the renewable energy project developer faces. Success in the CDM has been linked to appropriate timing between project development activities and the CDM approval process. Many of the projects in the Caribbean did not have the adequate timing and therefore opportunities have been missed in several countries.

Furthermore, the Caribbean Region has only submitted two Programs of Activities (PoA) under the CDM. Therefore the CDM PoA has so far failed to be instituted as dissemination vehicle for small scale project activities in the Caribbean region, although there is a clear potential for such schemes, especially as the region commits to large scaling-up efforts for renewable energy deployment.

The findings of the study indicate that the mitigation component of such a major scaling-up is on the order of up to 440 million tons of CO_2 by 2030, a figure that was found to be relevant and significant within the regional energy sector emission profiles. Taking into account new emerging opportunities for climate mitigation finance such as pilot NAMA facilities as well as, under discussion, new market mechanisms; there is a space for leveraging resources that could prove to be synergistic in supporting the removal of barriers for the implementation of region wide efforts to scale up renewable energies.

From the study it seems recommendable to hold a regional discussion on establishing a road map for the envisioned support expected within the region from emerging and existing climate finance mechanisms, including carbon markets. The aim should be to assess what leverage and degree of engagement the climate offices in the region should have in focusing opportunities for climate mitigation funding opportunities identified. Based on such a discussion a new road map should emerge on how the region proposes to gain incidence within existing and emerging climate mitigation financing opportunities. From this the formation of financial facilities could be secured, which can leverage resources at the scale needed in order to remove barriers for scaling up of renewable energy in the region.

Climate Change institutions and related policy making in the region will have to adjust and evolve under the new emerging opportunities. Important areas of attention for climate change institution development and strengthening in the near future need to be considered, such as:

- The need for new institutional leadership and capacity building as the climate action agenda furthers up and streamlines into broader incidence not only at the traditional UNFCCC level, but at the country level as well.
- The emerging opportunity to engage leadership and establishment of required partnerships for action on climate change mitigation, taking advantage of new windows of opportunity within climate financing and assistance in leveraging most needed resources for barrier removal towards scaling up renewable energy in the region.

9. References

Ochs, A., Fu-Bertaux, X., Konold, M., Makhijani, S., Shrank, S., Adkins, C. 2011. Roadmap to a Sustainable Energy System: Harnessing the Dominican Republic's Wind and Solar Resources Worldwatch Institute. Washington, DC. Available at: http://www.worldwatch.org/sustainable-energy-roadmaps

AMA, 2009: GEO Cuba 2007 - Evaluación del medio ambiente cubano - Capítulo VI. Escenarios socioeconómicos y ambientales 2004-2050 (Escenarios), Agencia de Medio Ambiente, La Habana, Cuba

BNamericas, 2012: Electric Power – Cuba, Cuba to begin building 50MW wind farm next year, Available at: http://www.bnamericas.com/news/electricpower/cuba-to-begin-building-50mw-wind-farm-next-year

Carbono 2012. Curbelo, A., Jiménez, O., Suárez, Y. Oportunidades de proyectos para la reducción de emisiones de gases de efecto invernadero utilizando Agroresiduos. Cuba. ISBN: 978-959-713-689-7

CARICOM, 2013: Energy Policy 2013. Available at: ttp://www.caricom.org/jsp/community_organs/energy_programme/CARICOM_energy_policy_march_2013.pdf

CELAC, 2013: Comunidad de Estados Latinoamerica, Available at: http://www.celac.gob.ve/index.php?lang=en

CUBAENERGIA, 2012: Perez, D., López, I., Somoza, J., Villarroel, J., Soler, B.

Evaluación de Opciones de Mitigación de Gases de Efecto Invernadero en el sector energético cubano. Proyecto Carbono 2012, Informe Final. 46 p.

CUBAENERGIA, 2012: Participación de las Fuentes de energía renovables en América Latina y el Caribe. Resumen Ejecutivo. CUBAENERGIA. Julio 2012. Available at : http://www.cubaenergia.cu

CUBAENERGIA, 2012: Curbelo, A., Jimenez, O., Suarez, Y. Oportunidades de proyectos para la reducción de emisiones de gases de efecto invernadero utilizando Agroresiduos. Proyecto Carbono 2012, Informe Final. 47 p.

CUBAENERGIA, 2012. Pérez, D., López, I. Sostenibilidad Energética. 7mo Taller Internacional de Energía y Medio Ambiente. Cienfuegos. Cuba. 2012. ISBN: 978-959-257-323-9.

ECLAC, 2012: Statistical Yearbook for Latin America and the Caribbean, Economic Commission for Latin America and the Caribbean. Published in Spanish as: CEPAL, Anuario estadístico de América Latina y el Caribe, 2012

EDGAR database, 2013: The Emission Database for Global Atmospheric Research, version 4.2. Available at: http://edgar.jrc.ec.europa.eu

ENERDATA, 2012: Global Energy & CO_2 Data, Available at: http://www.enerdata.net/enerdatauk/knowledge/subscriptions/database/energy-market-data-and-co2-emissions-data.php

GMI, 2011: Resource Assessment for Livestock and Agro-Industrial Wastes - Dominican Republic, Global Methane Initiative, March 2013

Government of Guyana, 2012: Second national communication to the United Nations Framework Convention on Climate Change. Georgetown, 2012

Government of Belize, 2011: Second National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change. Belmopan, Belize. 146 p.

IPCC, 1996: Revised IPCC Guidelines for National Greenhouse Gas Inventories. Vol1-3. UK Meteorological Office, Bracknell. Available at: http://www.ipcc-nggip.iges.or.jp/public/gl/invs4.html

IPCC, 2007: Climate Change 2007: Mitigation of climate change, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, 2007.

IPCC, 2013: Climate Change 2013: The Physical Science Basis. Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available in http://www.ipcc.ch/report/ar5/wg1/

IRENA, 2012: Renewable Power Generation Costs in 2012: An overview. Available at: http://www.irena.org/DocumentDownloads/Publications/Overview_Renewable%20Power%20Generation%20Costs%20in%202012.pdf

IRENA, 2012b: Renewable Energy Technologies: Cost Analysis Series, Volume 1: Power Sector, Issues 1-5, June 2012

Jargstorf, B. 2011: Wind Power in the Caribbean: ongoing and planned projects 2011. Factor 4 Energy Projects GMBH. GIZ/CARICOM. St. Lucia.

OAS, 2011: Energy Policy and Sector Analysis in the Caribbean (2010-2011), Assessing Antigua and Barbuda; the Bahamas, Dominica, Grenada, St. Lucia, St. Kitts and Nevis; and St. Vincent and the Grenadines, Organization of American States (OAS) and the National Renewable Energy Laboratory, under the Energy and Climate Partnership of the Americas (ECPA)

OLADE, 2005: “Prospectiva del Sector Energía en los Países de México, América Central y el Caribe”. Vol.4. Quito, Ecuador. 219 p.

OLADE, 2008: Estudio de país: Barbados; Proyecto: Energía y Cambio Climático, Fase IV: Desarrollo de Estudios de Caso y Fortalecimiento de Capacidades para al MDL, Latin American Energy Organization, November, 2008.

OLADE. 2013: Study on the Identification of Potential Project Portfolios Associated to Programmatic CDM and NAMAs in Jamaica, Prepared by Dr. Oscar Coto, Jamaica, March 2013.

PETROCARIBE. 2007: Estudio sobre Energías Renovables en El Caribe. Secretaria PETROCARIBE, Diciembre 2007. Available at http://petrocaribe.org

Ramírez, R. 2007: Reporte de gestión y resultados de la secretaria de PETROCARIBE. Ministerio de Energía y Minas de Venezuela. Available at: http://www.pertocaribe.org

REN21, 2012. RENEWABLES 2012. Global Status Report. Paris, France.171p. Available at : www.ren21.net

Santamarta Flórez, José, 2013: Cuba will show its progress in World Wind Energy Conference, Available at: http://santamarta-florez.blogspot.com.es/2013/05/cuba-will-show-its-progress-in-world.html

Thomson Reuters Point Carbon, 2013: Carbon 2013 - At a Tipping Point, March 2013

UNEP Risø Centre, 2013: Emission Reduction Profile – Belize, June 2013

UNEP Risø Centre, 2013b: CDM Pipeline, November 2013, Available at: http://cdmpipeline.org/

UNFCCC, 2013: Status of Ratification of the Kyoto Protocol, Available at: http://unfccc.int/kyoto_protocol/status_of_ratification/items/2613.php

UNFCCC, 2013b: Trend of types of PoA Entering Validation, Available at: http://cdm.unfccc.int, June 2013

World Bank, 2010: Caribbean Regional Electricity, Generation, Interconnection, and Fuels Supply Strategy - Final Report, Nexant, March 2010

Annex 1. Input data for Base and Mitigation scenarios

This annex presents information related to data used for the generation of BASE and MITIGATION scenarios used in modelling potential emissions reductions due to scaling up of RE Technologies in the targeted Caribbean countries, as well as detailing results of the potential emissions reductions to 2030 in each country in the region as well as to show the main results in greater detail.

For each of the 16 countries:

- The source of input data for the calculations is provided.
- The annual generation capacity growth is estimated, considering the growth rate assumed.
- The generating capacity to be added each year of the study period is determined, bearing in mind the installed capacity in the base year
- The generation capacity structure in the BASE scenario is defined, taking into account the matrix generating capacity in the base year.
- The generation capacity structure in the MITIGATION scenario is determined, based on the introduction of renewable energy capacities, in line with the renewable energy potential identified in the country (not based on techno-economic viability of specific projects) and assuming that renewable energy penetration shall reach circa 20% in 2020 and 30% in 2030.
- Once the generating capacity structure in the two scenarios has been determined, avoided emissions are calculated.
- By establishing the difference between the respective scenarios, avoided fuel use can be determined and from there avoided emissions reductions based on the standard consideration of fuel emission factors for the respective fuels in each scenario.

There is a table for each of the countries including the following information:

Pc - the generating calculated capacity, considering the growth rate assumed for the country.

P1 - The generating capacity at the beginning of each period.

P2 - Newly introduced total generation capacity in each period.

P3 – Capacity Generation at the end of each period (Capacity at the end of the period).

Pre - Newly renewable energy capacity in MITIGATION scenarios incorporated in each period.

The table shows the cumulative CO_2e avoided each year, calculated by:
screening.xl.templates. It shows the difference of the MITIGATION scenario compared to the BASE scenario.

A.1.1. Antigua and Barbuda

In 2010 the country had an installed capacity of 90.2 MW, with a 314.2 GWh of electricity generation (ENERDATA). It has been estimated that the average annual growth rate of electric power capacity for the coming years is about 3.3% (World Bank).

The installed generation technology in the country is based on diesel engines (DE-100%).

The wind and sun are the most promising renewable energy resources available in the country, being both resources reported to reach about 450 MW in some prospective studies.

In the BASELINE scenario, the demand for new electric power potential is satisfied by using diesel engines.

Growth estimates indicate that the electric power potential in the first stage (i.e. from 2010 till 2020) requires the addition of 35 MW in new capacities and in the second (from 2020 till 2030), another 50 MW will be required.

In the MITIGATION scenario, 30 MW of wind power are introduced in the first phase and 25 MW in the second. Consequently, a level of penetration of renewable energy of 24% and 31% are reached in the first and second stage respectively.

Year	Pc	P1	P2	Rre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	90	90			90	
2011	93	90			90	
2012	96	90			90	
2013	99	90	15	15	105	
2014	102	105			105	80,766
2015	106	105			105	188,454
2016	109	105	20	15	125	323,064
2017	113	125			125	484,596
2018	117	125			125	646,128
2019	121	125			125	807,660
2020	125	125			125	969,192
2025	147	125	25	25	150	1,949,912
2030	173	150	25		175	2,930,632
Total			85	55		2,930,632

A1.2. Bahamas

In 2010 the country had an installed capacity of 548 MW, with an electricity generation of 2195.70 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity for the coming years is about 3.1% (estimated by the authors using data from the NREL study, OAS).

The power generation technology installed in the country mainly relies on diesel engines.

The wind and sun are the most promising renewable energy resources available to the country, being both resources reported to reach about 116 MW in some prospective studies.

In the BASELINE scenario, the new electric power potential is assumed by using diesel engines (DE-100%).

For the first stage the addition of 200 MW in new capacities is required and 270 MW for the second stage.

In the MITIGATION scenario 100 MW of renewable energy are introduced (50 MW from wind and 50 MW from solar energy) in the first stage, so that the hitherto identified potential is exhausted. With this addition, a 13% penetration of renewable energy is to be reached by 2020. In order to get at least 20% of renewable energy penetration by 2030, about 100 MW is required to be installed in the second stage.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	548	548			548	
2011	565	548			548	
2012	583	548			548	
2013	601	548	100	50	648	
2014	619	648			648	436,938
2015	638	648	100	50	748	873,876
2016	658	748			748	1,310,814
2017	679	748			748	1,747,752
2018	700	748			748	2,184,690
2019	721	748			748	2,621,628
2020	744	748			748	3,058,566
2025	867	748	120	100	868	5,766,713
2030	1010	868	150		1018	6,963,230
Total			470	200		6,963,230

A1.3 Barbados

In 2010 the country had an installed capacity of 239.1 MW, with an electricity generation of 1,047.30 GWh (ENERDATA). It has been estimated that the average annual growth rate of electric power capacity for the coming years is about 3.5% (World Bank).

The power generation technology installed in the country is mainly based on diesel engines (DE -75%), and the rest is made up by some steam and gas turbines (GT -25%).

The wind, residues and the sun are the most promising renewable energy resources available in the country. All the three mentioned resources contribute with a total potential of about 140 MW.

In the BASELINE scenario, the demand of new electric power capacity is met with diesel engines (75%) and gas turbines (25%).

Expansion requires adding 100 MW in new capacities in the first phase and 140 MW in the second stage.

In the MITIGATION scenario, 70 MW of renewable energy are introduced (60 wind and 10 solar) in the first stage, which reaches a penetration of 21% of renewable energy by 2020. The remaining 66 MW of renewable potential are introduced in the second stage, achieving a penetration of 28% by the year 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	239	239			239	
2011	247	239			239	
2012	256	239			239	
2013	265	239	50	50	289	
2014	274	289			289	269,225
2015	284	289	20	20	309	538,450
2016	294	309			309	895,065
2017	304	309	30		339	1,251,680
2018	315	339			339	1,608,295
2019	326	339			339	1,964,910
2020	337	339			339	2,321,525
2025	400	339	70	66	409	5,832,009
2030	475	409	70		479	9,342,494
Total			240	136		9,342,494

A1.4. Belize

In 2010 the country had an installed capacity of 82.9 MW, with an electricity generation of 7.608 GWh and imported 475.66 GWh (ENERDATA).

Of the electricity consumed in Belize, about 50% is imported from Mexico and the rest comes from hydro powers (25%), diesel (20%) and burning sugarcane biomass residues (5%). It has been estimated that the average annual growth rate of electric power capacity in the coming years is about 8.3% (estimated by the authors using data from the Second National Communication of the country).

The country's potential in water resources, wind, solar and biomass reported in different studies, totals circa 340 MW.

In the BASELINE scenario, the demand of new electric power potential is assumed using diesel engines (DE- 57%) and hydroelectric power plants (H-43%), considering that this is the structure of national electricity production.

Growth estimates of electric power capacity indicate that 80 MW in new capacities are additionally required in the first stage and 260 MW in the second stage.

In the MITIGATION scenario 10 MW of hydropower are introduced in the first stage, thus reaching a penetration of 23% of renewable energy by 2020. In the second stage, 80 MW (60 wind and 20 solar) are introduced, reaching a penetration of 29% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	83	83			83	
2011	90	83			83	
2012	97	83			83	
2013	105	83	35	10	118	
2014	114	118	25		143	53,845
2015	124	143			143	107,690
2016	134	143			143	161,535
2017	145	143	20		163	215,380
2018	157	163			163	269,225
2019	170	163			163	323,070
2020	184	163	30		193	376,915
2025	274	198	80	80	278	1,987,840
2030	408	278	150		428	4,940,465
Total			340	90		4,940,465

A1.5. Cuba

In 2010, the total installed capacity in the country was 5,852.6 MW and electricity generation amounted to 17,395.5 GWh (CUBAENERGÍA).

Out of the generated electricity, 3.2% is from renewable sources and 96.8% from fossil-fuel based facilities. The majority of these facilities are thermal power plants (61%), diesel engines (23%) and gas turbines and combined cycle (14%).

It has been estimated that the average annual growth rate of electric power capacity for the coming years is about 2.5%.

The country's estimated potential in renewable energy exceeds 8,000 MW considering wind, solar, biomass, hydro, residues and ocean current energies.

In the BASELINE scenario, new electric power capacity is assumed with thermal power plants using fuel and crude oil (TP-60%), diesel engines (DE-25%) and gas turbines and combined cycle (GTCC-15%), similar to the existing structure to generate electricity at present.

Growth estimates of electric power capacity indicate that the first stage requires adding 1600 MW in new capacities and the second stage 2,150 MW.

In the MITIGATION scenario, 600 MW of wind power and 400 MW of hydropower are introduced in the first stage, reaching a penetration of 15% of renewable energy by 2020. In the second stage 1,800 MW of renewable energy (biomass 1,200, Wind 400 and Solar 200) are introduced, representing a penetration of 30% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	5,853	5,853			5,853	
2011	5,999	5,853			5,853	
2012	6,149	5,853			5,853	
2013	6,303	5,853	700	100	6,553	
2014	6,461	6,553	100	100	6,653	548,449
2015	6,622	6,653	100	100	6,753	1,096,898
2016	6,788	6,753	200	200	6,953	2,595,718
2017	6,957	6,953	200	200	7,153	5,044,909
2018	7,131	7,153	200	200	7,353	9,139,447
2019	7,310	7,353	100	100	7,453	13,238,023
2020	7,492	7,453			7,453	17,336,601
2025	8,477	7,453	1,200	1,200	8,653	69,236,936
2030	9,590	8,653	950	600	9,603	123,879,516
Total			3,750	2,800		123,879,516

A1.6. Dominica

In 2010, the installed electric power capacity in the country was 26.7 MW and electricity generation amounted to 92.9 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity for the coming years is about 2.7% (World Bank).

The installed electric power technology in the country is mainly based on diesel engines (75%), and the rest in hydropower plants.

Dominica has a large renewable energy potential, amounting to nearly 400 MW (300 geothermal, 45 solar, 30 wind and 17 hydro).

In the BASELINE scenario, new electric power potential is generated using hydro power (H-25%) and diesel (DE-75%), similar to the existing structure of electricity production nowadays.

Growth estimates of electric power capacity indicate that the first stage requires adding 10 MW of new capacities and the second stage 10 MW.

In the MITIGATION scenario, 10 MW of wind power are included in the first stage, thus reaching a penetration of 28% of renewable energy by 2020. In the second stage, 10 MW of geothermal power are added, reaching a penetration of 42% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	27	27			27	
2011	28	27			27	
2012	28	27			27	
2013	29	27	10	10	37	
2014	30	37			37	53,845
2015	31	37			37	107,690
2016	32	37			37	215,380
2017	32	37			37	323,070
2018	33	37			37	430,760
2019	34	37			37	538,450
2020	35	37			37	646,140
2025	41	37	10	10	47	1,184,590
2030	46	47			47	1,992,265
Total			20	20		1,992,265

A.1.7. Dominican Republic

In 2010, the total installed electric power capacity in the country was 3,344 MW and electricity generation amounted to 5,794.98 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity for the coming years is about 3.4% (World Bank).

Within the installed technologies, 16% corresponds to hydropower plants, 39% to gas turbines and combined cycle, 23% to steam turbines and 24% to diesel engines.

The estimated renewable energies generation potential in the country exceeds 8,000 MW in wind, solar and hydro.

In the BASELINE scenario, the new electric power potential is generated using hydro power (H-10%), fuel thermal power (TP-20%), diesel engines (DE-20%) and gas turbines and combined cycle(GTCC-50%).

Growth estimates of electric power capacity indicate that the first stage requires adding 1,400 MW in new capacities and the second stage 1,800 MW.

In the MITIGATION scenario, 650 MW (350 corresponding to wind power and 300 to hydro) of renewable energy will be introduced in the first stage, to achieve a penetration of 24% of renewable energy by 2020. In the second stage 1,000 MW of renewable energy (hydro 300, wind 300 and solar 400) will be introduced, reaching a penetration of 32% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	3,344	3,344			3,344	
2011	3,458	3,344			3,344	
2012	3,575	3,344			3,344	
2013	3,697	3,344	500	350	3,844	
2014	3,823	3,844			3,844	1,884,573
2015	3,952	3,844	300	300	4,144	3,769,146
2016	4,087	4,144			4,144	7,141,611
2017	4,226	4,144	300		4,444	11,939,633
2018	4,369	4,444	300		4,744	16,737,655
2019	4,518	4,744			4,744	21,535,677
2020	4,672	4,744			4,744	26,333,699
2025	5,522	4,744	1,000	1,000	5,744	71,861,785
2030	6,526	5,744	800		6,544	117,389,871
Total			3,200	1,650		117,389,871

A1.8. Grenada

In 2010, the installed capacity in the country was 55.8 MW and electricity generation amounted to 205.82 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity for the coming years will be about 5.4% (World Bank).

All the Installed technologies (100%) are diesel (DE-100%).

In the country, the estimated renewable energy potential, which is wind and solar, is 40 MW.

In the BASELINE scenario, new electric power potential is assumed using diesel engines.

Growth estimates of electric power capacity indicate that the first stage requires adding 40 MW in new capacities and the second stage 60 MW.

In the MITIGATION scenario 20 MW of wind power will be introduced in the first stage, to achieve a penetration of 21% of renewable energy by 2020. In the second stage 25 MW of solar photovoltaic power will be included, thus reaching a penetration of 29% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	56	56			56	
2011	59	56			56	
2012	62	56			56	
2013	66	56	15	15	71	
2014	69	71			71	80,766
2015	73	71	10		81	161,532
2016	77	81	5	5	86	269,220
2017	81	86	10		96	376,908
2018	85	96			96	534,192
2019	90	96			96	691,476
2020	95	96			96	848,760
2025	112	96	20	20	116	2,054,460
2030	160	116	40	5	156	3,694,130
Total			100	45		3,694,130

A1.9 Guyana

The installed capacity in the country in 2010 was 348.5 MW and electricity production amounted to 765 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity in the coming years will be about 3.3% (estimated by the authors using data from the Second National Communication of the Guyana).

Over 99% of the installed technologies are steam turbines.

The country's estimated potential in renewable energy exceeds 7,000 MW, mainly from water resources (Second National Communication of Guyana).

In the BASELINE scenario, the new electric power capacity is assumed using diesel (DE-100%). Growth estimates of electric power capacity indicate that the first stage requires adding 320 MW in new capacities and the second stage 380 MW.

In the MITIGATION scenario, 200 MW of hydropower capacity will be introduced in the first stage, to achieve a penetration of 18% of renewables by 2020. In the second stage, other 160 MW of hydropower will be included, thus reaching a penetration of 25% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	765	765			765	
2011	790	765			765	
2012	816	765			765	
2013	843	765	100	100	865	
2014	871	865			865	475,186
2015	900	865	100		965	950,372
2016	930	965			965	1,425,558
2017	960	965	100	100	1,065	2,375,930
2018	992	1,065			1,065	3,326,302
2019	1,025	1,065	20		1,085	4,276,674
2020	1,058	1,085			1,085	5,227,046
2025	1,244	1,085	160	160	1,245	14,690,021
2030	1,464	1,245	220		1,465	24,152,996
Total			700	360		24,152,996

A1.10 Haiti

In 2010 the installed capacity in the country was 338 MW and power generation reached 645.23 MW (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity is about 5% for the coming years (World Bank).

Eighteen percent of the installed technologies are hydropower plants and 82% steam turbines.

The estimated renewable energy potential in the country by 2030 exceeds 19.0 MW, mainly from water, solar and wind power.

In the BASELINE scenario, the new electric power potential is assumed using steam turbines (ST-100%).

Growth estimates of energy power capacity indicate that the first stage requires adding 220 MW in new capacities and the second stage 350 MW.

In the MITIGATION scenario, 50 MW of hydropower will be introduced in the first stage, to achieve a penetration of 18% of renewables by 2020. In the second stage 160 MW solar photovoltaic are introduced, reaching a penetration of 29% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	338	338			338	
2011	355	338			338	
2012	373	338			338	
2013	391	338	100	50	438	
2014	411	438			438	371,973
2015	431	438	100		538	981,539
2016	453	538			538	1,591,105
2017	476	538			538	2,200,671
2018	499	538			538	2,810,237
2019	524	538	20		558	3,469,399
2020	551	558			558	4,128,561
2025	703	558	150	150	708	11,551,956
2030	897	708	200		908	19,843,290
Total			570	200		19,843,290

A1.11 Jamaica

In 2010 the installed capacity in the country was 854 MW and electricity generation amounted to 5435.84 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity will be about 4.3% in the coming years (World Bank).

The shares of the installed technologies are 5% renewable energy (hydro and wind), 81% for steam turbines and 14% for gas turbines.

In the country, the estimated renewable energy potential is 785 MW, which includes hydropower, wind, solar and residues.

In the BASELINE scenario, the new electric power potential is assumed with steam (ST-80%) and gas turbines (GT-20%).

The estimated growth in energy power capacity indicates that the first stage requires the addition of 500 MW in new capacities and the second stage 630 MW.

In the MITIGATION scenario 235 MW of renewable energy (25 hydro, wind 70, 100 solar and biomass 40) will be introduced in the first stage, to achieve a penetration of 21% of renewables by 2020. In the second stage 300 MW solar PV will be introduced, reaching penetration of 29% in 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	854	854			854	
2011	891	854			854	
2012	929	854			854	
2013	969	854	200	25	1,054	
2014	1,011	1,054			1,054	831,136
2015	1,054	1,054	100	70	1,154	1,662,272
2016	1,099	1,154			1,154	2,851,580
2017	1,147	1,154	100	100	1,254	4,040,888
2018	1,196	1,254			1,254	5,378,985
2019	1,247	1,254	100	40	1,354	6,865,871
2020	1,301	1,354			1,354	8,352,757
2025	1,605	1,354	300	300	1,654	20,818,567
2030	1,982	1,654	330		1,984	37,376,077
Total			1,130	535		37,376,077

A1.12. Saint Kitts and Nevis

In 2010, the installed power capacity in the country and electricity production was of 48 MW and 233 GWh respectively (World Bank).

The World Bank estimated that the average annual growth rate of electric power capacity in the coming years will be 3.5% in Saint Kitts and 5.2% in Nevis.

All installed technologies are diesel engines.

The estimated renewable energy potential in the country is 340 MW, mostly from resources, which are the most promising source for the country.

In the BASELINE scenario, the new electric power potential is assumed with diesel engines (DE-100%).

The estimated growth in energy power capacity indicates that the first stage requires adding 30 MW in new capacities and the second stage 30 MW.

In the MITIGATION scenario, 20 MW of geothermal energy will be introduced in the first stage, to achieve a penetration of 25% of renewables by 2020. In the second stage, an additional 10 MW of geothermal power will be introduced, reaching penetration of 28% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	48	48			48	
2011	50	48			48	
2012	52	48			48	
2013	54	48	10	10	58	
2014	56	58			58	107,690
2015	58	58	10	10	68	215,380
2016	61	68			68	323,070
2017	63	68			68	430,760
2018	66	68			68	538,450
2019	68	68	10		78	646,140
2020	71	78			78	753,830
2025	86	78	10	10	88	1,346,125
2030	107	88	20		108	1,938,420
Total			60	30		1,938,420

A1.13. Saint Lucia

In 2010, the installed capacity in the country was of 76 MW and electricity generation of 380.889 GWh (ENERDATA).

It has been estimated that the average annual growth rate of electric power capacity in the coming years will be about 3.2% (World Bank).

All the installed technologies are diesel engines.

The estimated potential in renewable energy in the country is 250 MW, being the most promising geothermal resources as they represent the highest share, but there are also wind (40 MW) and solar energy potential (36 MW).

In the BASELINE scenario the new electric power potential is assumed with diesel engines (DE-100%).

The estimated growth in energy power capacity indicates that the first stage adding 30 MW in new capacities and the second stage 40 MW.

In the MITIGATION scenario 20 MW of wind energy will be introduced in the first stage, to achieve a penetration of 19% of renewables by 2020. In the second stage 40 MW of geothermal energy will be introduced, reaching penetration of 27% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	76	76			76	
2011	78	76			76	
2012	81	76			76	
2013	84	76			76	
2014	86	76	10	10	86	53,844
2015	89	86	10	10	96	161,532
2016	92	96			96	269,220
2017	95	96	5		101	376,908
2018	98	101			101	484,596
2019	101	101	5		106	592,284
2020	104	106			106	699,972
2025	122	106	20	20	126	1,776,852
2030	143	126	20	20	146	2,853,732
Total			70	40		2,853,732

A1.14. Saint Vincent and the Grenadines

In 2010, the installed electric power capacity in the country was 36 MW and electricity generation amounted to 156.464 GWh (ENERDATA).

The World Bank estimated that the average annual growth rate of energy power capacity in the coming years will be circa 6.9%.

Twenty two percent of the installed technologies are hydropower plants and the rest are diesel engines.

The estimated potential of renewable energy in the country is of 145 MW, of which geothermal sources represent the biggest share. However, there is a moderate potential available of harvesting energy from water, wind and the sun.

In the BASELINE scenario, the new energy power potential is assumed to come from diesel engines (DE-100%).

The estimated growth in energy power capacity indicates that the first stage requires adding 40 MW in new capacities and the second stage 65 MW.

In the MITIGATION scenario 10 MW of hydropower energy will be introduced in the first stage, to achieve a penetration of 24% of renewables by 2020. In the second stage 25 MW of geothermal energy will be introduced, reaching penetration of renewables of 31% by 2030.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	36	36			36	
2011	38	36			36	
2012	41	36			36	
2013	44	36	10	10	46	
2014	47	46			46	47,519
2015	50	46	10		56	95,038
2016	54	56			56	167,355
2017	57	56	10		66	239,672
2018	61	66			66	336,787
2019	66	66	10		76	433,902
2020	70	76			76	531,017
2025	98	76	25	25	101	1,937,662
2030	136	101	40		141	3,344,307
Total			105	35		3,344,307

A1.15 Surinam

In 2010, the installed capacity in the country was 411 MW and energy generation amounted to 1634.7 GWh (ENERDATA).

Based on data from the country's GDP growth and energy intensity reduction, it has been estimated than the average annual growth rate of electric power capacity in the coming years will be about 2.0%.

The most widespread technologies in the country are steam turbines and hydropower plants.

The estimated renewable energy potential in the country is of 2.50 MW mainly from water resources.

In the BASELINE scenario, the new electric power potential is assumed with steam turbines (ST-54%) and hydropower plants (H-46%).

The estimated growth in energy power capacity indicates that the first stage requires to add 100 MW in new capacities and the second stage another 100 MW.

In the MITIGATION scenario 50 MW of renewable energy will be introduced in the first stage, to achieve a penetration of 46% of renewables by 2020. In the second stage 60 MW of renewable energy could be introduced.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	411	411			411	
2011	419	411			411	
2012	428	411			411	
2013	436	411	50	50	461	
2014	445	461			461	269,225
2015	454	461	50		511	538,450
2016	463	511			511	807,675
2017	472	511			511	1,076,900
2018	482	511			511	1,346,125
2019	491	511			511	1,615,350
2020	501	511			511	1,884,575
2025	553	511	40	40	551	4,846,050
2030	610	551	60	20	611	7,807,525
Total			200	110		7,807,525

A1.16 Trinidad and Tobago

Trinidad and Tobago has the greatest reserves of natural gas in the Caribbean. Consequently, it is a net producer and exporter of hydrocarbons. In 2010, the installed capacity in the country was of 1,554 MW and electricity generation amounted to 8,331.16 GWh (ENERDATA).

OLADE estimated that the average annual growth rate of energy power capacity in the coming years will be circa 5.6%.

The most disseminated technologies are steam turbines (85%) and gas turbines (15%).

Trinidad and Tobago has neither significant hydroelectric nor geothermal potential. Although its solar and wind resources have not been assessed, it has been estimated that 500 MW of wind power could be generated. It has been estimated that in the coming years around 500 MW wind power could be generated (OLADE).

In the BASELINE scenario, the new electric power potential is assumed by using steam turbines (ST-100%).

The estimated growth in energy power capacity indicates that the first stage requires adding 1,200 MW in new capacities and the second stage 1,800 MW.

In the MITIGATION scenario 400 MW of wind energy will be introduced in the first stage, to achieve a penetration of 14% of renewables by 2020. A failure to identify a new renewable energy potential and to be exploited in the second stage, i.e. if the expansion is only based on the use of fossil fuels, then the penetration of RE would drop to 9% by 2030. To achieve a 29% penetration of renewables by 2030, it will be required to install 800 MW in such technologies in the second stage. Even though the solar energy potential has not been evaluated yet, it has been considered that it could be identified and its introduction could be feasible in the second stage.

Year	Pc	P1	P2	Pre	P3	Accumulated avoided CO_2 emissions (tCO_2e)
2010	1544	1544			1544	
2011	1630	1544			1540	
2012	1722	1540			1540	
2013	1818	1540	400	400	1944	
2014	1920	1944	100		2044	2,153,798
2015	2028	2044	200		2244	4,307,596
2016	2141	2244	200		2444	6,461,394
2017	2261	2444			2444	8,615,192
2018	2388	2444	100		2544	10,768,990
2019	2521	2544	200		2744	12,922,788
2020	2662	2744			2744	15,076,586
2025	3495	2744	800	800	3544	46,783,871
2030	4590	3544	1000		4544	78,491,156
Total			3000	1200		78,491,156

Annex 2. Criteria for the selection of targeted renewable energy Technologies used in assessing potential for PoA interventions in the Caribbean

1. Sufficient information is available on the proposed sectors and the countries are willing to provide it to the study. (Classification of the most active sectors, according to SIEE)

2. There are national or regional studies on the proposed sectors, which is reflected in the public information system of each country. (There is information grouped by sectors: Sufficient (S), Medium (M), Insufficient (I)),

3.There are technical assessments of the sectoral potentials in the participating countries. (Definition of technical evaluations on potentials in the proposed sectors: Sufficient (S), Medium (M), Insufficient (I)),

4. The participating countries have established policies and incentives to facilitate the penetration of renewable energies in a specific period of time. (Definition of policies or goals in the proposed sectors: Sufficient (S), Medium (M), Insufficient (I)),

5. The future investment projects related to renewable energy are identified in the sectors under study. (Economic contribution and sustainability as investment proposals by 2020 in each country: Sufficient (S), Medium (M), Insufficient (I)),

6. There is available the country basic data to calculate the specific sectoral mitigation potential. (Possibilities of the sector to get incentives through carbon markets: Sufficient (S), Medium (M), Insufficient (I)),

7. Existence of sectoral development policies in each participating country. (Development and implementation of sustainable policies for these sectors);

8. Existing CDM projects with its corresponding CDM approved methodologies for the chosen sectors. (Number of CDM projects in different development status).

9. Future GHG emission reductions per sector (global GHG emission reductions achieved through CDM projects by the countries in the Caribbean region).

The following table shows the criteria assessment applied to evaluate the eight technologies considered in the study.

SECTOR	Criteria to evaluate by sector (the score evaluated is in parentheses)								Criteria 2-8
	1	2	3	4	5	6	7	8	9	Score
Biomass	X	S	S	S	M	M	S	$X_{(1)*}$		6,0
Biofuels	X	M-I	M-I	I	I	I	M-I	-		1,2
Biogas (swine manure)	X	S	S	M	M	M	M-S	$X_{(2)*}$		5,2
Biogas (landfill)	X	S	S	M	S	S	M-S	$X_{(5)*}$		6,2
Wind	X	S	S	S	S	S	S	$X_{(12)*}$		7,0
Geothermal	X	M-S	M	M-I	I	I	M	-		2,2
Hydro	X	S	S	S	M-S	S	S	-		5,7
Solar PV and Thermal	X	M-S	M-S	S	S	S	S	$X_{(2)*}$		6,6

Source: Elaborated by the authors

Ranking score for the criteria:
S: Score 1
M-S: Score 0.7
M: Score 0.5
M-I: Score 0.3
I: Score 0.1

*: Number of projects

Criteria numbers 1 and 9 were not considered in the evaluation because their contribution was not relevant for the classification of sectors in the countries considered for the study. However a preliminary analysis was performed only to deal with the most likely renewable energy sources to be implemented in the Caribbean region in the future. In exceptional conditions, as in the selecting country procedure, a specific sector could be also admitted, in line with the characteristics required by such study, provided that the countries in question agree and adopt the proposed sector.

Seven criteria were considered with a weighting value ranging from 0.1 to 1 according to the classification methodology used. The score values ranged from 0.1, 0.3, 0.5, 0.7 and 1 corresponding to the classification of sufficient, medium-sufficient, medium, medium-insufficient and inadequate respectively. For the evaluation, it was considered only the three sectors with the higher score to represent the criteria of the region. In the same way there are additional criteria to be assessed and which are relevant for the development of Programme such as: i) information provided by the sectors; ii) sectoral development in the region or even at country level; iii) development of programmes and projects in the most advanced sectors; iv) estimated GHG emission reductions by sector; v) penetration of sectoral development programmes in the countries; vi) previous sectoral studies assessing potential future investments.

According to the criteria defined the two best scored sectors were wind and solar. The next sectors with similar scores are biogas from landfills and biomass from agriculture, followed by biogas from swine manure.

The biogas from landfills was excluded due to the weak existing experience of the Caribbean region in landfill projects, its CDM performance and its relative low contribution in terms of creating new capacities.

This publication has been produced with the
assistance of the European Union

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http://www.uneprisoe.org/
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